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Applied Mechanics Reviews

A Critical Review of the World Literature in Applied Mechanics

L. H. DONNELL, *Editor*

T. VON KÁRMAN, S. TIMOSHENKO, *Editorial Advisers*

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Abbreviations of units follow the standard of Abbreviations for Scientific and Engineering Terms of the AM. Standards Assoc. Examples: psi (pounds per square inch); cps (cycles per second); mph (miles per hour).

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Applied Mechanics Reviews

A Critical Review of the World Literature in Applied Mechanics

April 1949 Vol. 2, No. 4

General Kinematics, Statics, Dynamics

(See also Revs. 428, 523, 532, 534, 554)

416. **V. M. Tatevsky, "The characteristic functions and the equations of dynamics"** (in Russian with English summary), *Vestnik Moskov. Univ.*, 1947, no. 5, pp. 83–105.

The author considers the general equations of dynamics in terms of the variable systems $(\dot{p}_i, p_i)$ and $(\dot{q}_i, p_i)$ (the index i will be omitted hereafter). If H is Hamilton's function, and if

$$M = H + \Sigma \dot{p}q, \quad K = M - \Sigma p\dot{q}$$

then

$$\frac{\partial M}{\partial p} - \frac{d}{dt}\frac{\partial M}{\partial \dot{p}} = 0, \quad \frac{\partial K}{\partial \dot{j}} = -\dot{p}, \quad \frac{\partial K}{\partial \dot{p}} = \dot{q}$$

and, if $\partial K/\partial t = 0$,

$$\frac{\partial \dot{K}}{\partial \dot{q}} = -\dot{p}, \quad \frac{\partial \dot{K}}{\partial \dot{p}} = \dot{q}.$$

The variational principles

$$\delta \int M dt = 0, \ \Delta \int \dot{p}(\partial M/\partial \dot{p})dt = 0$$

hold. The variation Δ is isoenergetic.

The analogs of the various forms of dynamic equations (except the Hamilton-Jacobi one) follow, all expressed in the new variables with no particularly simple forms appearing. The theory of small oscillations in the variables p, $\dot{p}$, is developed in complete parallel to its familiar form. A case of order reduction,

$$M = (p^2/2m) + F(\dot{p}),$$

for one degree of freedom, imitates the harmonic oscillator

$$L = (\dot{q}^2/2m) + F(q).$$

The exposition is elementary and detailed, which accounts for the length of the paper. A. W. Wundheiler, USA

417. **Wilhelm Blaschke, "On integrals in kinematics (Über Integrale in der Kinematik),"** *Arch. Math.*, 1948, vol. 1, no. 1, pp. 18–22.

J. Steiner [*Gesammelte Werke*, 1882, vol. 2, pp. 99–159; *J. reine angew. Math.*, 1840, vol. 21, pp. 33–63, 101–133] established a formula for the area enclosed by the trajectory of a point in a periodic coplanar motion of a plane rigid system. The author extends Steiner's result to the rotation of the rigid body about a fixed point and to the general motion of a rigid body in three-space.

Courtesy of Mathematical Reviews W. Prager, USA

418. **C. Zwikker, "Vectorial theory of gear wheel tooth profiles,"** *Appl. sci. Res. Sec. A*, 1948, vol. 1, no. 2, pp. 139–150.

The complex variable is applied to gear teeth in the determination of tooth shapes, the path of the point of contact and the slip. The most common tooth profile, the involute, is expressed by $z = a(1 - j\omega)\exp(j\omega)$. The epicycloidal profiles, which are sometimes used, are given by $z = (n + 1)a\exp(j\omega)$, while the trochoids traced by points on the moving gears are given by

$$z = a_1 \exp(jn_1\omega) + a_2 \exp(jn_2\omega).$$

Courtesy of Mathematical Reviews M. Goldberg, USA

419. **Jean Mandel, "On the invariance of the equations of mechanics in a change of the reference system (Sur l'invariance des équations de la mécanique dans un changement du système de référence),"** *C. R. Acad. Sci. Paris*, Aug. 2, 1948, vol. 227, pp. 326–328.

This note is devoted to some general considerations concerning the invariance of dynamical equations under transformations of the system of reference. Since the author does not specify exactly what transformations he is discussing, his reasoning and conclusions remain somewhat vague. The reviewer has not found any results in the note that can be regarded as essentially new.

Courtesy of Mathematical Reviews L. A. MacColl, USA

420. **O. N. Korsakov, "Displacement of mechanisms with cylindrical gear wheels"** (in Russian), *Bull. Acad. Sci. USSR Ser. tech. Sci. (Izv. Akad. Nauk SSSR Ser. tekh. Nauk.)*, Aug. 1948, no. 8, pp. 1297–1312.

This paper came out of the error-analysis school of Brooyevich and harks back to the latter's book [*The Precision of Mechanisms*, Tehteoretizdat, 1946]. The procedure of Bihovsky's paper, "Accuracy of mechanisms controlled by ordinary differential equations" [see Rev. 1078, July 1948], is applied to the title problem. The variation of the displacement is expressed in terms of seventeen primary variations ("errors") regarded as random quantities with Gaussian distribution. The expected value and the standard deviation are determined, neglecting "second-order" quantities.

The expected value of the error is zero for a population of mechanisms. The maximum displacement error is also expressed to the first order, and is discussed and represented by several graphs. A. W. Wundheiler, USA

421. **John L. Synge and B. A. Griffith, "Principles of mechanics,"** McGraw-Hill Book Co., New York, 1949, 2nd ed. Cloth, 9.2 × 6 in., 530 pp., 164 figs., $5.

This second edition of the familiar book differs from the first one in the following respects:

1 The discussion of the motion of a particle in an electromagnetic field (Chapter XIII) has been completely rewritten.

2 In Chapter XI, the treatment of principal axes of inertia has been amplified. Minor changes have been made in the exposition of the theories of Foucault's pendulum, the spinning projectile and the gyrocompass.

3 A few paragraphs have been added on units and dimensions, encouraging the reader's interest in the Appendix, which is devoted to the theory of dimensions. A. W. Wundheiler, USA

422. S. Timoshenko and D. H. Young, "Advanced dynamics," McGraw-Hill Book Co., New York, 1948. Cloth, 9 × 6 in., 400 pp., 279 figs., $5.50.

Engineers and engineering schools in the United States have been guided out of a difficult situation by the teachings and textbooks of Professor Timoshenko. Before his arrival an almost unscalable precipice had developed between the levels of knowledge of mechanics here and in Europe. The teaching of mechanics in engineering schools here had gradually been tailored to suit the limited needs and capacities of the large numbers of students demanded by expanding industries. Even today most of our students receive only elementary training in mechanics, and could not absorb much more. They choose to enter applied rather than pure science, both for economic reasons and because they have not attained the intellectual maturity at which abstractions become palatable.

Formerly those who did attain such maturity found that their training had not prepared them for further progress. To make such progress they would have had to transfer to physics or mathematics for a fresh start which would have led them eventually to the mechanics of Whittaker, Love and Lamb, by-passing the great body of useful engineering applications. Professor Timoshenko made it practicable to devise curriculums in several branches of mechanics which progress directly from introductory courses to the threshold of the highest levels. His building blocks are concrete applications, acceptable to practical-minded engineers and immediately useful in industry. This has both stimulated and made it possible to meet an increasing demand for engineers with intermediate training in mechanics, at the same time opening the gate wide for engineers to enter the field of research.

Advanced Dynamics is the third fruitful collaboration of the authors, and occupies about the same position between their *Engineering Mechanics* and Whittaker's *Analytical Dynamics* as Timoshenko's *Theory of Elasticity* occupies between his *Strength of Materials* and Love's *Elasticity*. The reader is introduced to the main theorems of particle and rigid-body dynamics by easy stages. The mathematical tools employed are elementary; scalar notation is used throughout and illustrative examples are worked out in great detail.

Much of Chapter I, on dynamics of a particle, is devoted to methods of numerical and graphical integration. Rectilinear and plane motion are treated and the applications, for the most part, are to linear and nonlinear vibrations and to various ordnance problems.

The principles of linear and angular momentum and conservation of energy are introduced in Chapter II. Balancing of reciprocating engines and flywheel problems are treated in detail and ordnance problems are again present in the form of the exploding shell and the rocket, including the flight of a variable-mass rocket to the moon. Classical chain, impulse and pendulum problems are briefly discussed. The reader is introduced painlessly to the elements of generalized coordinates and forces and Lagrange's equations, during a discussion of the reciprocating engine. He is thus prepared for the extensive treatment of these topics in the following two chapters.

The fifth and last chapter deals with rigid-body motion about a fixed point, leading to a concise introduction to gyroscopics. The book closes with a short appendix on dynamic similarity, in which Buckingham's pi-theorem is introduced by means of examples. Numerous historical references are given throughout, as well as references to more specialized books, recent developments and applications. There are numerous problems as well as worked-out examples.

A significant feature, in a book on particle and rigid-body dynamics, is the frequent use of the theory of flexure of beams in illustrations and applications of such topics as the law of conservation of energy (p. 168), generalized coordinates (p. 204) and Lagrange's equations (p. 306). The authors' point of view is well illustrated by the treatment according to Hamilton's Principle. On p. 233 they say, "In general. . . . the use of this principle does not simplify the solution of problems dealing with systems having a finite number of degrees of freedom. However, it may have some advantages in the case of elastic systems with an infinite number of degrees of freedom and has found some useful applications in various branches of physics." Engineers can understand and approve such an attitude as this. R. D. Mindlin, USA

Gyroscopics, Governors, Servos

(See also Rev. 533)

423. John R. Moore, "Application of servo systems to aircraft," *Aero. Engng. Rev.*, Jan. 1949, vol. 8, pp. 32–43, 71.

This is a general expository paper on the current state of the art. The scope of applications to aircraft steering is indicated, present popular methods of design are briefly sketched, and probable trends of future developments are discussed. The possibility of exploiting combinations of open cycle and closed cycle systems is noted. Stephen H. Crandall, England

424. M. Gerard Lehmann, "Recent progress in determining the precision and stability of servomechanisms (Progrès récents dans la détermination de la précision et de la stabilité des servomécanismes)," *Mémor. Artill. fr.*, 1947, vol. 21, no. 2, pp. 505–536.

This paper is a review of recent developments in the techniques of servomechanism design. The American reader will not find anything new in it, as it is based primarily upon work of American origin. However, it is a rather complete and well-written exposition of the application of the frequency-scanning methods, that is, the Nyquist and Bode diagrams.

Charles Concordia, USA

425. Jean Daniel, "Accelerating the speed control of hydraulic turbines (Accélération du réglage de vitesse des turbines hydrauliques)," *Houille blanche*, 1948: Jan.-Feb., pp. 7-33; Mar.-Apr., pp. 147–182.

This article presents a comprehensive theoretical discussion of the stability and performance of speed governors for hydraulic turbines. It is a serial of more than 60 pages. Various ways of mathematically determining the stability are compared and effects of such factors as hydraulic head and rotor and water inertia are studied. It is proposed to use a temporary response to the water pressure at the turbine to improve performance and stability, and examples are presented to show the improvement obtained. Charles Concordia, USA

Vibrations, Balancing

(See also Revs. 427, 447, 464, 514, 539)

426. C. R. Freberg and Emory N. Kemler, "Elements of mechanical vibration," John Wiley & Sons, New York, 1949. Cloth, 9.25 × 6 in., 227 pp., 131 figs., $3.75.

The second edition of this book includes a new chapter on the vibration of beams, and a new chapter on sound which presents a discussion at the engineering level of sound measurement and soundproofing. The use of the Holzer tabulation method for multimass systems is discussed at greater length than in the

previous edition and illustrative examples of the use of the method are presented for both torsional and linear systems.

The book is intended primarily for use as a text in elementary courses in vibrations, and treats problems which can be solved by the use of the simpler types of differential equations, by approximate and numerical methods, or by Firestone's mobility method.

John E. Goldberg, USA

Wave Motion, Impact

(See also Revs. 539, 556)

427. C. A. **Coulson, "Waves,"** Oliver and Boyd, London, 1947. Cloth, 7.25 × 4.9 in., 159 pp., 30 figs., $2.25.

The author treats from an elementary standpoint a large number of illustrations of wave propagation, such as waves in membranes and bars, sound and electric waves, diffraction and polarization problems, wave packets and retarded potentials, and some relatively advanced problems in water waves. Boundary-value problems are presented with care and featured as the unifying aspect. Harvey Cohn, USA

428. **Manley St. Denis, "Dynamic strength,"** *J. Amer. Soc. nav. Engrs.*, Nov. 1948, vol. 60, pp. 505–540.

This paper does not deal with the dynamic strength of materials but with the stresses in elastic systems subjected to certain types of impulsive loads (step pulse, single sine pulse, blast pulse). The presentation is elementary. Illustration is by problems involving stresses in ship's flight deck due to aircraft landing, and in ship's deck plate subjected to blast pressure. M. P. White, USA

429. P. L. **Carlotti, "Study of a swell at a finite depth. Note on 'total reflection' (Étude de la houle en profondeur finie. Note sur la 'reflexion totale'),"** *Houille blanche*, Mar.-Apr. 1947, vol. 2, pp. 112–116.

In this case, the hydrodynamic analogy of a phenomenon well known in optics leads to a new and interesting result which is not present in the original model. In dealing with the total reflection of water waves (long gravitational) at an interface in ocean depth, the free surface is clearly continuous, and therefore the surface wave resulting from the interference of the incident and the reflected wave has marked effects on the high-velocity side of the barrier, in contrast to the optical case.

These effects have the form of wakes similar to those that would be produced in the rear of evenly spaced obstacles progressing along the line at which the reflection occurs. As much as one half the incident energy can in this fashion be propagated into the deeper water, regardless of the "total" reflection of the oncoming wave. Experimental verification and further application of these results would be extremely interesting.

Joanne Starr Malkus, USA

430. **Arthur W. Carter, "Effect of hull length-beam ratio on the hydrodynamic characteristics of flying boats in waves,"** *Nat. adv. Comm. Aero. tech. Note*, no. 1782, Jan. 1949, pp. 1–44.

An investigation was made of the take-off and landing behavior in waves of models of a hypothetical flying boat having hull length-beam ratios 6 and 15. An increase of length-beam ratio from 6 to 15 reduced the maximum vertical acceleration during landing approximately 25 per cent, increased the maximum angular accelerations during landing 15 to 39 per cent and reduced the motions in trim and rise as well as the maximum trim and rise. Reductions in trim and rise would make landings in waves less hazardous with a hull of high length-beam ratio than with a hull of low length-beam ratio.

Inasmuch as the rate of deceleration used in these tests is considerably less than usually experienced in actual landing operations, the values given for maximum trim and rise are subject to some question. The take-off behavior with the high length-beam ratio was generally less violent and considerably less likely to reach a dangerous altitude during take-off than with the low length-beam ratio. Ernest G. Stout, USA

Elasticity Theory

(See also Revs. 440, 445, 467, 482, 525)

431. **Makoto Isida, "Solution of the tension problem of the strip with an elliptic hole, part I"** (in Japanese), *Appl. Math. Mech. (Oyō Sūgaku Rikigaku)*, Nov.-Dec. 1947, vol. 1, pp. 302–311.

The method of successive approximation used by R. C. J. Howland [*Phil. Trans. roy. Soc. Lond., Ser. A*, vol. 229, p. 49; vol. 232, p. 155] is applied to the strip with an elliptic hole. The maximum stress at the elliptic boundary is shown to be approximately equal to the sum of the maximum stresses for the cases of a circular hole with diameter $2b$ and with diameter $2(b/a - 1)T$, where $2b$ and $2a$ denote the diameters of the elliptic hole perpendicular and parallel to the straight boundary of the strip, and T denotes the tensile stress. S. Moriguti, Japan

432. **J. B. Diaz and A. Weinstein, "The torsional rigidity and variational methods,"** *Amer. J. Math.*, Jan. 1948, vol. 70, pp 107–116.

The stress distribution in a cross section (simply or multiply connected) of a cylinder under torsion can be found in terms of a stress function ψ which satisfies Laplace's equation, and certain boundary-value conditions. The torsional rigidity S of the cylinder is here shown to be expressible as an integral function of ψ in the form

$$S = P - D(\psi)$$

where P is the polar second moment of the cross section and $D(\psi)$ is the Dirichlet integral of ψ over the cross section. Although the distribution of ψ, and hence the value of S, is easily obtained numerically for any particular case, only in a very few such cases can the functional form of ψ be found. The authors prove certain general inequalities whereby upper and lower bounds can always be assigned for S and its value estimated, without requiring any knowledge, functional or numerical, of the form of ψ.

D. N. De G. Allen, England

433. **Fujio Hirano, "Calculation of the form factor of a two-dimensional elastic body, part I"** (in Japanese), *Appl. Math-Mech. (Oyō Sūgaku Rikigaku)*, 1947, vol. 1: Aug., pp. 109–120; Sept., pp. 179–188.

Muskhelishvili's method [*Z. angew. Math. Mech.*, 1933, vol. 13, pp. 264–282] is summarized and extended. Part I deals with the fundamental integrodifferential equation and the general principles of its solution. The extension to the case of a semi-infinite plate under loads on the bounding edge is due to the author.

S. Moriguti, Japan

Experimental Stress Analysis

(See also Rev. 451)

434. A. Pirard, "Torsion problems and the measurements of stresses by thin membranes (Les problèmes de torsion et les mesures de tensions par membranes minces)," *Rev. univ. Min.*, Oct. 1948, vol. 4, pp. 527–539.

This paper discusses in detail the experimental measurement of stresses in uniform torsion bars of arbitrary cross section by the use of the membrane analogy. The means of obtaining precision results from the membrane are described quite completely. Certain irregular cross sections are investigated, such as the circular sector, the split annular ring, and a wide-flanged beam, and the shearing stress isostatics for these cases are pictured. The extension of the membrane method to the evaluation of the sum of the principal stresses in photoelastic analysis is described.

Louis F. Coffin, Jr., USA

435. F. Aughtie, "The use of resistance strain gauges in combination, with particular reference to the measurement of component loads," *Proc. 1946 Conf. Manchester and District Branch Inst. Phys. Lond.*, 1948, pp. 27–41.

The general problem of load measurement by means of strain gages is discussed. The author shows how the necessary circuits can be derived, and outlines the general case of the use of n gages interconnected so that any one of the quantities can be determined directly, and the remaining $n-1$ quantities eliminated. The paper is not concerned with solution of the elastic problems which may be involved. Three illustrative examples are given.

R. L. Bisplinghoff, USA

436. D. E. Thomas, "Measurement of internal stresses by x-rays," *Inst. Metals Monogr. Rep. Ser.*, no. 5, 1948, pp. 25–30.

This paper is one of the contributions to the Symposium on Internal Stresses in Metals and Alloys organized by The Institute of Metals, London, October 1947. It deals with the back-reflection technique used for the measurement of internal stresses in metallic structures by the use of X rays. The author recommends cobalt radiation for the examination of iron, steel and aluminum, and nickel radiation for α brass. The use of normal and oblique incidence is explained and the limitations of the method are discussed. It is noted that the technique demands a well-constructed regular crystal lattice for measurable reflections, and so it is not so effective when the lattice is not well formed. Thus, hardened steel cannot be investigated by this method; the same is true of plastically deformed metals. This paper with its clear photographs forms a valuable contribution for new workers anxious to obtain reliable results with this technique of nondestructive measurement of internal strains in metals. S. K. Ghaswala, India

437. W. A. Wood, "Some fundamental aspects of the application of x-rays to the study of locked-up stresses in polycrystalline metals," *Inst. Metals Monogr. Rep. Ser.*, no. 5, 1948, pp. 31–34.

This paper is one of the contributions to the Symposium on Internal Stresses in Metals and Alloys organized by The Institute of Metals, London, October 1947. It is a review of the author's past work and a survey of the various difficulties which arise in interpretation of the results of lattice stress-strain measurements. In differentiating between micro- and macrostresses, the conception of two successive stages in the analysis is brought out, namely the evaluation of elastic strains due to locked-up stresses and the conversion of these strains to their equivalent stresses.

The first stage is simple and straightforward, as it can be carried out by the oblique incidence method of Thomas provided the selective character of the particular reflecting plane used is duly considered (see the preceding review). The conversion of elastic strains into stresses, forming the second stage, presents difficulty. For this, a knowledge of the stress-strain curves for the particular spacings utilized is essential, especially because the stress-strain modulus obtained from mechanical testing is inapplicable, since in a polycrystalline metal this value is an average of all atomic spacing.

The paper concludes with a statement of precautions which should be observed to secure precision when measuring stresses by X rays. S. K. Ghaswala, India

438. E. P. George, "High-frequency strain gauges," *Proc. 1946 Conf. Manchester and District Branch Inst. Phys. Lond.*, 1948, pp. 42–48.

Theoretical and experimental investigation of thin ferromagnetic wires subjected to stresses are described. A comparison between the use of alternating current and direct current is made. The change of resistance of these wires due to tension was found to be much greater for high-frequency alternating current than for direct current. Under condition of equal high-frequency alternating-current dissipation and direct-current dissipation the signal was 40 times greater using 20 megacycles per sec alternating current than with direct current. R. K. Bernhard, USA

439. K. Heindlhofer, "Evaluation of residual stress," McGraw-Hill Book Co., New York, 1948. Cloth, 8 × 5.5 in., 196 pp., 81 figs., $4.

This book, published as one of a series in Metallurgy and Metallurgical Engineering, obviously has been intended to give metallurgists an understanding of residual-stress problems and means of measurement of residual stresses, but will be of little general value to mechanologists working in this field.

The opening chapters discuss the common causes of residual-stress conditions and are noteworthy chiefly for suggesting that nonuniform phase changes in metals may result in "locked-in" stresses. This is followed by a review of the stress-strain relationships including the various graphical constructions based upon Mohr's circle, and by a short chapter on the mapping of residual stresses, which leans heavily upon photoelasticity. The next chapter, which probably is the most important one, discusses the method generally used for evaluation of residual stresses, namely Mathar's method of measuring the dimensional changes across a drilled-in hole, trepanning of plates, Rosenthal and Norton's and Sachs's progressive sectioning and machining, and the nondestructive method of measuring the interatomic pacing by X-ray diffraction at the surface.

This is followed by a chapter on strain gages, devoted mainly to an elementary treatment of the bonded-wire resistance gage, and finally by a chapter giving actual examples of residual-stress evaluation.

There is considerable doubt that the science of residual-stress measurement has reached a state which justifies the writing of a book devoted to this subject. John E. Goldberg, USA

Rods, Beams, Shafts, Springs, Cables, etc.

(See also Revs. 428, 451, 476)

440. Othon Drechsel, "Calculation of helicoidal gears with nonparallel axes (Calcul des engrenages hélicoïdaux à axes non parallèles)," *Rev. univ. Min.*, Dec. 1948, vol. 4, pp. 689–712.

This paper reviews the properties of helicoidal gears with nonparallel axes and presents the well-known Hertz theory for calculating stresses in bodies subjected to contact pressures. The

Hertz theory is then applied to the determination of the stresses in the teeth of helicoidal gears. Tables, graphs and illustrated examples are given to explain fully the application of the theory.

Joseph Marin, USA

441. **J. R. Finniecome, "Thrusts and stresses in two-dimensional pipe expansion bends,"** *Proc. Instn. mech. Engrs.*, 1948, vol. 158, no. 3, pp. 369–384.

The author considers two-dimensional pipe expansion bends. Formulas are stated from which the thrusts and moments in the pipe can be determined, once the linear and angular deflections are known. These formulas incorporate the von Kármán flexibility factor, and involve several line integrals along the pipe. Bends of several shapes are considered, with several different sets of end conditions; the integrals arising in each case are evaluated and the results presented in tabular form for convenience in practical applications.

G. E. Hay, USA

442. **Zusse Levinton, "Elastic foundations analyzed by the method of redundant reactions,"** *Proc. Amer. Soc. civ. Engrs.*, Dec. 1947, vol. 73, pp. 1529–1541.

A method for solving problems of beams on elastic foundations is described, which consists of setting up simultaneous equations for the pressures at a number of equally spaced points along the beam. In expressing the deflections at these points the approximation is made that the pressure variation between each pair is linear.

D. N. De G. Allen, England

443. **C. Massonnet, "Is it necessary to introduce the Bernoulli hypothesis in the resistance of materials? (Est-il nécessaire d'introduire l'hypothèse de Bernoulli en résistance des matériaux?),"** *Bull. Soc. Sci. Liège*, Dec. 1947, vol. 16, pp. 301–306.

The author shows that Bernoulli's hypothesis regarding plane cross sections remaining plane for simple traction and torsion, and pure bending of long prisms in the resistance of materials can be derived directly from certain considerations of symmetry.

Henry Favre, Switzerland

444. **D. G. Sopwith, "The production of favourable internal stresses in helical compression springs by pre-stressing,"** *Inst. Metals Monogr. Rep. Ser.*, no. 5, 1948, pp. 195–207.

This paper is one of the contributions to the Symposium on Internal Stresses in Metals and Alloys organized by The Institute of Metals, London, October 1947. Applications of the principles of prestressing to helical compression springs are discussed in this paper, and it is shown that by compressing the spring to closure several times its ultimate load-carrying capacity is increased considerably. In the experiments carried out the springs were hot-wound from one cast of silicomanganese steel (B.S.S. En.45).

After investigating the underlying process, the distributions of stresses under load and residual stresses are derived. Starting from the formula given by Nádai for skin stress induced by a given torque, it is shown that the negative residual stress is half the increase in elastic range due to prestressing. Applications of this principle to various problems arising in the design of such springs are given, together with an appendix containing formulas and charts for stresses in circular and rectangular sections.

S. K. Ghaswala, India

445. **J. F. Downie Smith, "Rubber springs—shear loading—II,"** *Trans. Amer. Soc. mech. Engrs.*, Apr. 1948, vol. 70, pp. 227–232.

The author develops analytical expressions in the form of infinite series for the deflection of various types of rubber springs such as the single and double-shear sandwich with linearly varying height, the single and double cylindrical disk sandwiches with constant radial thickness, and coaxial torsion bushings with constant axial length and with length decreasing linearly with increasing radius.

In his closure the author states that the first two terms of the series in general give the necessary accuracy for all cases of shear pads, but if loads are light it may be sufficient to use the first term only.

Nicholas Sag, Australia

446. **Michel Bakhoum, "Normal stresses in reinforced concrete sections under unsymmetrical bending,"** *J. Amer. Concr. Inst.*, Apr. 1948, vol. 19, pp. 669–691.

In this paper there is considered a reinforced concrete beam with a general cross section. The beam is bent either by a force parallel to the generators of the surface of the beam, or by a couple with axis perpendicular to these generators. The object of this paper is the determination of the stresses in the beam. This is accomplished by first making a guess as to the location of the neutral axis of the cross section. This guess is then improved upon until the desired accuracy is obtained, by a repeated consideration of the equilibrium of the force system acting across the cross section. Three different approaches to this iteration problem are presented, and are illustrated by several numerical examples.

G. E. Hay, USA

Plates, Disks, Shells, Membranes

(See also Revs. 454, 462)

447. **H. G. Hopkins, "The solution of small displacement, stability or vibration problems concerning a flat rectangular panel when the edges are either clamped or simply supported,"** *Rep. Memo. aero. Res. Counc. Lond.*, no. 2234, June 1945 (issued in 1948), pp. 1–18.

A method is presented for computing displacements of a rectangular plate due to uniform lateral loading, buckling loads or vibratory motion. The plate may have stiffeners and may be aeolotropic. The solution is assumed as an infinite series of functions, each of which satisfies the boundary conditions. The variation of each term in the x-direction is taken as a sine function plus a cubic polynomial in x having four coefficients which may be chosen to satisfy any combination of simply supported or fixed-edge conditions. The variation in the y-direction is similar.

The potential and kinetic energies of the system are determined and substituted into Lagrange's equations, thus obtaining a system of linear algebraic equations governing the coefficients of the series. Numerical values of the integrals that arise in the energy expressions are tabulated for terms of the series up to and including the fourth harmonic.

Numerical solutions are given for the vibration of a square plate with fixed edges and for shear buckling of a square plate with one edge simply supported and three edges fixed.

Stanley U. Benscoter, USA

448. **Eric Reissner, "Stresses and small displacements of shallow spherical shells. II,"** *J. Math. Phys.*, Jan. 1947, vol. 25, pp. 279–300.

A method of solution is given by the author for the equations of the theory for rotationally symmetric bending and stretching of shallow spherical shells developed previously in Part I [*J. Math. Phys.*, 1946, vol. 25, pp. 80–85]. It is shown that the two simul-

taneous fourth-order equations may be reduced to two independent second-order equations. The two equations are then solved for the case of rotational symmetry.

Explicit results are given for three problems: (*a*) a shell with no edge restraint carrying a point load at the apex; (*b*) a shell with no edge restraint carrying a load uniformly distributed over a small circular area with center at the apex; (*c*) a shell with edge restraint carrying a point load at the apex. Numerical results are included in the form of curves. It is also shown that the method may be used to solve a problem of pure bending of curved bars. The general results are presented in such a manner that future applications to other conditions of loading and support are facilitated.

In the development of the equations, the linear theory has been followed. It might be pointed out that the nonlinear terms neglected are particularly important in this type of structure, once the deflection is no longer small in comparison with the thickness of the shell. C. T. Wang, USA

449. Eric Reissner, "Note on the membrane theory of shells of revolution," *J. Math. Phys.*, Jan. 1948, vol. 26, pp. 290–293.

In this paper there are considered problems without axial symmetry in the linear membrane theory of shells of revolution. In the case of such problems there are three equations of equilibrium. By the introduction of a stress function these equations can be replaced by a single second-order partial differential equation. Two such stress functions have been proposed, one by A. Pucher and one by P. Németyi. In the present paper the connection between these two stress functions is established.

G. E. Hay, USA

450. H. A. Lang, "Large cylindrical bending of rectangular plates," *J. appl. Mech.*, Dec. 1948, vol. 15, pp. 335–343.

This paper extends the problem of the cylindrical bending of a long thin rectangular plate, as considered in the first chapter of Timoshenko's *Plates and Shells*, to the case in which the curvature is large. The author proves the invariance of a certain function which may be described as the first integral of the differential equation of equilibrium. Solutions are obtained by use of power series in conjunction with this invariance. The convergence is made rapid by appropriate transposition of terms.

The problem of the rectangular plate clamped at the edges, under uniform load, is discussed in detail. Results indicate that the solution obtained by elementary theory (that is, by use of the approximate expression for curvature) is very accurate. In the case of bending under edge forces only, the use of the power series yields the expansion of the elliptic function solution. The author shows how to extend the solution for continuous loading to cases of discontinuous loading. S. B. Batdorf, USA

451. M. C. Caplan, L. B. W. Jolley, and J. Reeman, "Some internal stresses in turbine rotors," *Inst. Metals Monogr. Rep. Ser.*, no. 5, 1948, pp. 139–152.

The first part of this report describes experiments undertaken to determine whether internal stresses induced in a turbine wheel during fabrication and heat-treatment would, when combined with the centrifugal stresses, be sufficient to produce permanent set during the first running to full speed. Measurements were made by a microscope of the radial movement during rotation of datum lines scribed on the wheel surface. For a special unbladed wheel, first in the fully annealed condition, and then in the normalized and tempered condition, the radial movement was found to agree closely with elastic theory, and return to zero speed indicated no permanent set. In the case of a bladed production wheel, however, permanent set was found to occur after the first run-up.

The second part treats the problem of shaft deflection during subjection to high temperature. It is pointed out that temperature-deflection curves are of three major types: Type A is heat-stable and shows no deflection after long periods at temperature. Type B shows a permanent set after the first heating, due probably to relief of internal stress introduced during fabrication. Type C shows a deflection dependent on temperature and is probably due to variations in coefficients of thermal expansion across the shaft. Equations and plots are presented for estimation of deflections for types B and C. S. S. Manson, USA

452. W. Z. Chien, "Asymptotic behavior of a thin clamped circular plate under uniform normal pressure at very large deflection" (in English), *Sci. Rep. Nat. Tsing Hua Univ. Ser. A*, Apr. 1948, vol. 5, pp. 71–94.

This paper determines mathematically the conditions near the edge of an ideal isotropic elastic circular plate which carries a constant normal pressure and which is completely clamped at the boundary. The deflections are considered to be so large that the Hencky solution for a circular membrane is valid for the interior of the plate.

A numerical error, amounting to four per cent, was discovered by the author in Hencky's calculation of the deflections of a membrane. H. L. Langhaar, USA

Buckling Problems

(See also Revs. 447, 450)

453. P. P. Bijlaard, C. F. Kollbrunner, and F. Stüssi, "Theory and tests on plastic buckling of plates stressed by uniformly distributed longitudinal compression (Theorie und Versuche über das plastische Ausbeulen von Rechteckplatten unter gleichmässig verteiltem Längsdruck)" (with summaries in English and French), *Publ. int. Ass. Bridge Struct. Engng.*, 1948, Third Congress, prelim. publ., pp. 119–128.

Based on previous work by Bijlaard (see paper for bibliography), a theory is outlined describing the buckling loads for thin rectangular flat plates compressed beyond the elastic limit. Various edge-support conditions are accounted for, and it is assumed that the loading consists of simple longitudinal compression applied uniformly to the ends of the plate. In essence, the theory traces the reduction in plate stiffness when the elastic stresses are exceeded, based on data afforded by the simple stress-strain curve for the plate material.

The theoretical results are compared with test results previously reported by Kollbrunner and generally satisfactory agreement between the two is found. A specially constructed testing rig is then described and the results of a new series of tests are given. Again, the correlation between experiment and theory is excellent, well into the plastic range. By interpreting the plate results in terms of a simple column analogy, the significance of the findings is made apparent to the practicing engineer.

Martin Goland, USA

454. H. L. Cox and J. R. Riddell, "Sandwich construction and core materials, part III. Instability of sandwich struts and beams," *Rep. Memo. aero. Res. Counc. Lond.*, no. 2125, Dec. 1945 (issued in 1948), pp. 1–16.

Conditions of instability are formulated for sandwich struts with orthotropic core materials. For the Euler type of insta-

bility the critical load is given by the conventional formula with a correction for shear rigidity. Wrinkling of the skin under combined uniform compression and bending is dependent upon two critical strains which correspond to "in-phase" and the "out-of-phase" modes of deformation. It is shown that for many practical core materials, when the core thickness is more than 50 times the skin thickness, these two critical strains are almost equal. Therefore, when the strain in the heavily compressed skin exceeds the critical value, wrinkling type of failure will occur.

Conrad C. Wan, USA

455. **N. M. Newmark, "A simple approximate formula for effective end-fixity of columns,"** *J. aero. Sci.*, Feb. 1949, vol. 16, p. 116.

This paper gives simple approximate formulas for numerical values of the end-fixity coefficient of a uniform bar with elastic restraints at the ends and subject to compressive forces. In one form the equation is in error by less than four per cent and is valid for all finite amounts of stiffness against rotation. No theoretical background is given. Marshall Holt, USA

456. **G. C. Best, "Notes on column end-fixity coefficients,"** *J. aero. Sci.*, Feb. 1949, vol. 16, pp. 117–119.

A theory is developed for the relation between the elastic end restraint and the fixity coefficient for uniform bars subjected to axial compressive loads. The usual assumptions of small deflections and elastic action are made. From a graphical representation an approximate equation is developed which has sufficient accuracy for engineering purposes. An illustrative problem is solved. A comparison is made with Newmark's approximate equation (see preceding review). Marshall Holt, USA

457. **George L. Gallaher, "Plate compressive strength of FS-1h magnesium-alloy sheet and a maximum-strength formula for magnesium-alloy and aluminum-alloy formed sections,"** *Nat. adv. Comm. Aero. tech. Note*, no. 1714, Oct. 1948, pp. 1–23.

Formed Z and channel sections of magnesium-alloy sheet were tested to determine the stresses at which local instability of the plate elements occurs. By plotting these stresses against the calculated elastic critical strain for the same members, points are obtained which lie quite close to the compressive stress-strain curve for the material.

An empirical formula is developed for computing the stress at maximum load based on values observed in the above tests. The formula appears to be valid for a limited number of materials and cross-sectional shapes. John T. Kirkland, USA

458. **E. H. Schuette, "Observations on the maximum average stress of flat plates buckled in edge compression,"** *Nat. adv Comm. Aero tech. Note*, no. 1625, Feb. 1949, pp. 1–23.

An analysis is made of data from a number of tests, which had been made at a previous time, of flat plates buckled in edge compression. Data are gathered together and plotted, making use of nondimensional parameters. Results are related in such a way that the plotted points fall in fairly straight lines on log-log coordinates. When the test results are plotted using parameters involving the maximum average stress, buckling stress, and compressive yield stress an equation relating these quantities can be set up.

The author shows clearly what range of stress values he is considering, a region beyond the elastic range and not yet in the high-stress region. A theoretical explanation for the equation and for the simple form which it takes is attempted. It is admittedly inadequate, but is presented mainly to stimulate other ideas.

Because the sizes of test specimens and test methods used in obtaining the data under observation are not given in this technical note, many readers will wish to refer to the published reports of the tests. The author lists these and other references in the bibliography. A. N. Zamboky, USA

Joints and Joining Methods

459. **R. A. Nihoul, "Characteristics of materials for welded structures (Les aciers pour constructions soudées)"** (with English and German abstracts), *Publ. int. Ass. Bridge Struct. Engng.*, 1948, Third Congress, prelim. publ., pp. 47–64.

This paper is a critical discussion of recommendations by a Belgian commission for investigating failures of welded structures which are characterized by brittle or intercrystalline fractures without any apparent deformation, and frequently extending far into the base metal. The commission sought to define the general requirements for weldability of steels under the conditions found in bridge construction, using the usual welding processes, with no general heating before, during or after welding.

Accordingly limits were prescribed for the chemical constituents C, P, S, Si, Mn. Weldments recommended for mechanical tests by the commission include, among others, specimens proposed by Campus, Kommerell and Hauptman, or in general those which in the judgment of the commission best demonstrate a steel's susceptibility to brittle fracture, aging, hardening and triaxial stress. Also discussed is a preliminary list of steels, proposed by the commission, which are considered suitable for various types of welding. F. Hymans, USA

460. **Leroy A. Beaufoy and A. Moharram, "Derived moment-angle curves for web-cleat connections"** (English with summaries in French and German), *Publ. int. Ass. Bridge Struct. Engng.*, 1948, Third Congress, prelim. publ., pp. 105–118.

This paper is concerned with the relationship between applied moment and the change in angle between a column and beam when a web-cleat connection is used. While there is considerable experimental evidence available for such joints having flange cleats only, experiments with web-cleat connections have been on a smaller scale.

The authors propose a theoretical approach to the web-cleat connection problem which utilizes moment versus angle of rotation curves obtained experimentally for flange-cleat connections. First assuming the neutral axis at the center (low-moment assumption) and then at the bottom of the connection (high-moment assumption), the authors obtain two moment-angle curves, the former being the most conservative. Such experimental curves as are available fall between the two theoretical curves.

Moment-angle curves are given for three typical standard web-cleat connections. Harry A. Williams, USA

Structures

(See also Rev. 538)

461. **J. Courbon, "Contribution to the statics of suspension bridges with stiffening girders (Contribution à la statique des ponts suspendus à poutre de rigidité)"** (with summaries in English and German), *Publ. int. Ass. Bridge Struct., Engng.*, 1948, Third Congress, prelim. publ., pp. 423–434.

Using the customary assumptions for the analysis of stiffened suspension bridges, the equation for the horizontal component of

the cable tension is derived. By introducing a special function, the equation is transformed into a new form. This new form of the equation yields exactly the same results as the other, but has the advantage, according to the author, of being much more rapidly solvable by successive approximations. Reasonable approximations for influence lines can be obtained, thus permitting the determination of maximum moments and shears in the stiffening girder. The procedure and equations are extended to include the analysis of suspension bridges with multiple spans and bridges with diagonal cables as well as self-anchored suspension bridges.

A qualitative discussion is given of the assumptions upon which the theory is based and their effect upon the accuracy of the results. A number of practical suggestions regarding the spacing of piers and types of stiffening girders are given. There are no actual examples worked out in the paper, nor is any comparison given with the trigonometric-series method for analyzing suspension bridges. Dana Young, USA

462. L. A. Yolton and J. A. Liska, "Tests of cargo flooring for aircraft," *For. Prod. Lab. Rep.*, no. 1550-B, Apr. 1947, pp. 1–31; no. 1550-C, Oct. 1947, pp. 1–57; no. 1550-D, Jan. 1948, pp. 1–24; no. 1550-E, June 1948, pp. 1–25.

Development and tests of various sandwich-type cargo floors for transport aircraft are reported. The floors consisted mainly of an aluminum-alloy-sheet wearing surface spot-welded to a dimple-sheet base, and aluminum-bonded to maple plywood and resin-treated-paper honeycomb core. Results of static and impact tests are described. Floors made with 24S-T Alclad aluminum, 0.064 in. thick on the upper surface and 0.025 in. thick at the lower facing, bonded to a $^3/_4$-in. resin-impregnated cotton-duck honeycomb core, were the most satisfactory tested.

R. K. Bernhard, USA

463. E. Contessini, "Method for direct determination of profiles of buttress dams, lightened and full (Metodo per determinazione diretta dei profili della dighe a speroni, alleggerite e piene)," *Energia Elett.*, July 1948, vol. 25, pp. 341–360.

The author generalizes the well-known equation of stability of gravity dams to apply to the case of buttress dams.

He introduces as a parameter the ratio of the buttress thickness to the buttress spacing, and calculates the gradient of the upstream face for a given safety factor against sliding. He also calculates the limiting gradient of the upstream face producing no tensile stress along the upstream face.

The method is illustrated by examples of different types of dams. Charles Jaeger, England

464. Friedrich Bleich, "Dynamic instability of truss-stiffened suspension bridges under wind action," *Proc. Amer. Soc. civ. Engrs.*, Oct. 1948, vol. 74, pp. 1269–1314.

The author traces the cause of dynamic instability to two separate and independent sources: (a) the shedding of vortices resulting in a periodic aerodynamic force at the windward side of the bridge deck, and (b) the distributed wind forces along the deck. Proceeding from the assumption that the former is very small for trusses and shallow girders (verified by experiment), the author determines the resulting force and couple by using Theodorsen's equations [*Nat. adv. Comm. Aero. Rep.*, no. 496] for a vibrating flat plate of infinite length.

The fundamental translatory and torsional modes of vibration of the suspension bridge and the generalized aerodynamic forces associated with each mode are then established by means of the Rayleigh-Ritz method. Lagrange's equations yield the characteristic frequency equation, from which the critical wind velocity, i.e., that velocity at which the structure will vibrate at constant amplitude, is determined. The theory is then extended to include the effects of structural damping and vortex shedding, the approach to the latter being semiempirical. A limited number of tests show good agreement between theory and experiment.

E. F. Masur, USA

465. J. R. Green and H. A. Wills, "A new tyre, brake and undercarriage testing machine," *Aircr. Engng.*, Jan. 1949, vol. 21, pp. 22–24.

Details are given of a testing jig designed and built in Australia for testing aircraft undercarriages, tires and brakes. Single-wheel units with static wheel loads from 2500 to 50,000 lb can be tested. Landings can be simulated with side load and drag. A 'dynamic' cycling test simulates 100 landings at full static load with maximum brake torque. The machine is adapted for research on shimmy of nose and tail wheels, on the effect on the life of the tires of heavy cross-wind landings, on the acceleration of the wheels during landing, etc. The part to be tested is dropped on, or held in contact with, a large inertia wheel. B. S. Cain, USA

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 439, 478, 486, 487, 490, 540)

466. Marie L. V. Gayler, "Age-hardening," *Inst. Metals Monogr. Rep. Ser.*, no. 5, 1948, pp. 255–264.

An integrated survey is given of explanations for age-hardening, and the experimental evidence in their favor. The author concludes that there is now sufficient evidence to deduce that in this process highly localized internal stresses are continuously produced first on a submicroscopic and then on a microscopic scale. The submicroscopic internal stresses are not associated with any visible change in the microstructure or X-ray diffraction spectra. The microscopic internal stresses account for the second increase in hardness in aluminum copper alloys and the only observable increase for other alloys. Decrease after the second maximum is due to precipitation on crystallographic planes. The author points out the importance in a creep test of the augmenting of the internal localized stresses by applied stress.

D. C. Drucker, USA

467. Albert Kammerer, "Modulus of elasticity and endurance limit (Le module d'élasticité et la limite de fatigue)," *C. R. Acad. Sci. Paris*, Nov. 29, 1948, vol. 227, pp. 1144–1145.

Certain problems are briefly discussed in which the rate of strain, and the variation with strain of Young's modulus, are not negligible factors.

Attention is confined mainly to the solution of the equations where

$$\left.\begin{aligned} \sigma_i &= \frac{E_0(1-a\theta)}{1+\sigma}\left\{\frac{\sigma\theta}{1-2\sigma}+e_i\right\}+\lambda'\dot{\theta} \quad (i=1,2,3),\\ \sigma_1 &= N'+N''\sin(\omega t),\ \sigma_2=\sigma_3=0. \end{aligned}\right\} \quad (1)$$

The dilatation θ satisfies a generalized Riccati differential equation whose solution depends upon the solution of a differential equation of Mathieu type. It is deduced from the known character of the general solution of Mathieu's equation that, depending upon the relative magnitude of certain quantities, there is a bounded or an unbounded solution of (1). For a given value of

N' there is a critical value of N'', separating these two types of solution, which is identified as an endurance limit. The general results for this particular problem, and also for the problem of flexure, agree broadly with the known experimental results, which suggests practical application of the theory.

The reviewer is of the opinion that this theory merits development; if possible, the effect of nonlinear terms in the strains should be considered. H. G. Hopkins, England

468. P. S. **Symonds, "The determination of stresses in plastic regions in problems of plane flow,"** *J. appl. Phys.*, Jan. 1949, vol. 20, pp. 107–112.

A numerical-graphical method is presented for the calculation of stresses in plastic zones in ideally plastic materials. The procedure is applicable to problems of plane plastic flow in regions adjacent to boundaries of arbitrary shape. Application is made to cases involving plastic zones near elliptically shaped free boundaries, and the method is extended to cover the plastic action in a tensile bar containing elliptic notches of varying sharpness. Limitations of the method and the differences between these plane flow problems and related plane stress problems are discussed. T. J. Dolan, USA

469. G. **Krall, "Statics of so-called 'viscous' elastic mediums and its applications, I and II (Statica dei mezzi elastici cosidetti 'viscosi' e sue applicazioni),"** *R. C. Accad. Lincei*, 1947, vol. 2: Mar., pp. 233–237; Apr., pp. 371–377.

The performance of a viscous material under stress depends upon its stress-strain history, which the material "remembers." A performance function may be established as a function of the time at which the load is applied and the time at which the observations are made. On the basis of the results of Whitney and others for concrete, the author discusses the use of an exponential function for expressing deflections, effective modulus of elasticity, and other characteristics of the material. The effect of the stress distribution, throughout the material is discussed and a critical distribution multiplier is introduced into the analysis, leading to integral equations. Solutions for members subjected to axial loading and to flexure are discussed. Glenn Murphy, USA

470. O. S. **Parasyak, "Elastoplastic problem with nonbiharmonic plastic state"** (in Russian), *Notes Acad. Sci. USSR (Doklady Akad. Nauk SSSR)*, Dec. 1, 1948, vol. 63, pp. 367–370.

A flat infinite plate with a circular hole of radius R is subjected to biaxial stresses C and D at infinity, while normal stresses a and shear stresses b applied along the edge of the hole produce plastic flow in a region around the hole. In Galin's solution for the case $b = 0$ the stress function in the plastic zone appears in biharmonic form. When $b \neq 0$ the stress function will not be biharmonic. The case with $C = D = 0$ was solved by Michlin.

Michlin's stress distribution in the plastic zone is used to solve the present problem. The solution is based on a transformation in which the area outside the contour L defining the outer limit of the plastic region in the z-plane is transformed into an area outside a unit circle in the ζ-plane. The transformation used is $z = c(\zeta + \beta/\zeta)$ where $\beta = (D - C)/2k$ and c and k are constants. Walter W. Soroka, USA

471. H. F. **Bohnenblust and P. Duwez, "Some properties of a mechanical model of plasticity,"** *J. appl. Mech.*, Sept. 1948, vol. 15, pp. 222–225.

The mechanical model of a strain-hardening material discussed in the paper consists of a large number of elastic perfectly-plastic elements, each of which is characterized by its yield stresses in tension and compression or, what amounts to the same, the elastic strains ϵ and δ corresponding to these yield stresses. The mechanical behavior of the model can then be expressed in terms of the distribution $p(\epsilon, \delta)$ of the elements over the values of ϵ and δ. It is assumed that $p(\epsilon, \delta) = p(\delta, \epsilon)$, that is, that "in their totality the elements do not distinguish between elongation and contraction, although any particular element may show a preference for one direction." The stress-strain relations for loading and unloading are discussed; it is shown that the first does not completely determine the second, but only furnishes upper and lower bounds for it. These bounds are used to establish bounds for the potential energy.

Experiments of G. I. Taylor and his associates are evaluated in the light of this theory and found to be consistent with it.
Courtesy of Mathematical Reviews W. Prager, USA

472. **Alice Winzer and G. F. Carrier, "The interaction of discontinuity surfaces in plastic fields of stress,"** *J. appl. Mech.*, Sept. 1948, vol. 15, pp. 261–264.

The possibility of the existence of stress discontinuities across an interface within a plastic region in problems of plane strain has been pointed out by Prager. Denoting by t direction along, and by n direction normal to, such as interface, the stress condition for plasticity is

$$(\sigma_n - \sigma_t)^2 + 4\tau^2 = \text{const.}$$

For given σ_n and τ (continuous) this condition yields two roots for σ_t, a different one of which may obtain on either side of the interface.

The present paper considers such discontinuities (shocks) between regions of constant stress, and is particularly concerned with the possibility of the intersection of such shocks. Simple algebra shows that a minimum of four shocks can intersect at a point, and that a minimum of three shocks can intersect at the vertex of a "fan."

It should be remarked that the authors are concerned only with deductions drawn from the satisfaction of the stress condition for plasticity, and do not investigate the implications of any hypothesis regarding strain. D. N. De G. Allen, England

473. **A. J. Kennedy, "A method of fitting the Andrade creep equation to experimental results,"** *Proc. phys. Soc. Lond.*, Dec. 1948, vol. 61, pp. 510–515.

A mathematical treatment is given, which allows sliding templates to be used in finding the constants of Andrade's equation. No applications to actual curves are shown.

George Halsey, USA

474. **E. Siebel, "Graphical representation of strength properties (Graphische Darstellung der Festigkeitseigenschaften),"** *Stahl Eisen*, Jan. 1, 1948, vol. 68, pp. 23–24.

This paper presents a graphical representation of the strength properties by axonometric projection of the usual limiting surfaces. Advantage is claimed for this method in that all conditions of stress which differ only by a superimposed hydrostatic pressure are projected to the same point. C. O. Dohrenwend, USA

475. **A. H. Philippidis, "The general proof of the principle of maximum plastic resistance,"** *J. appl. Mech.*, Sept. 1948, vol. 15, pp. 241–242.

The author gives a general proof of the principle of maximum

plastic resistance proposed by Sadowsky [*J. appl. Mech.*, 1943] for an ideal plastic body. This principle may be stated as: "Among all statically possible stress distributions, the actual stress distribution in plastic flow requires a maximum value of the external effort necessary to maintain the flow."

As a starting point, the following assumptions are made regarding the stresses and strains in an ideal plastic body:

$$\sigma_x - \sigma_m = \lambda(\epsilon_x - \epsilon_m) \text{ etc., } \epsilon_m = (\epsilon_x + \epsilon_y + \epsilon_z)/3 = 0,$$

$$T_d = \text{const} = \sqrt{(\sigma_x - \sigma_m)^2 + (\sigma_y - \sigma_m)^2 + (\sigma_z - \sigma_m)^2 + 2(\tau_{xy}^2 + \tau_{yz}^2 + \tau_{zx}^2)}.$$

Small variations $\delta\sigma_x$, $\delta\sigma_y$, etc., in the stress components are taken; these satisfy the equilibrium conditions. The variations in the surface forces δX_ν, δY_ν, δZ_ν are expressed in terms of the variations in stress components $\delta\sigma_x$, $\delta\sigma_y$, etc., at the surface.

Next the integral $B = {}_V\int B_0 dV$ is formed, where $B_0 = T_d^2/2\lambda$. The variation δB is then expressed in terms of an integral containing products of the variations of the stress components and the partial derivatives of the displacement components u, v, w. Integrating by parts and using the equilibrium conditions and the expressions for the variations of the surface forces, the variation δB reduces to the expression:

$$\delta B = \delta\, {}_S\int (u_0 X_\nu + v_0 Y_\nu + w_0 Z_\nu) dS.$$

In this u_0, v_0, w_0 are the given displacements on the boundary and the integral is to be extended over the portion of the boundary where the displacements are given but the external forces are not given. Also $\delta B = \delta\, {}_V\int (T_d^2/2\lambda) dV = 0$ since T_d remains constant.

Since the integral ${}_S\int (u_0 X_\nu + v_0 Y_\nu + w_0 Z_\nu) dS$ represents the work of the external forces in moving through the displacements u_0, v_0, w_0, and since the variation of this integral δB is zero, this means that for an ideal plastic body this external effort reaches an extreme value in accordance with the principle proposed by Sadowsky. On this basis it is shown that for combined tension and torsion of a beam $\delta M_t = 0$ and $T = \text{const}$, or $\delta T = 0$ and $M_t = \text{const}$. For combined torsion and bending of a beam $\delta M_t = 0$ and $M_b = \text{const}$, or $\delta M_b = 0$ and $M_t = \text{const}$.

A. M. Wahl, USA

Failure, Mechanics of Solid State

(See also Revs. 467, 485, 487, 489, 490, 493, 535, 538, 555)

476. A. G. Warren, "Autofrettage," *Inst. Metals Monogr. Rep. Ser.*, no. 5, 1948, pp. 209–218.

Autofrettage (the overstressing of tubes by hydraulic pressure so as to set up residual stresses which enhance the load-carrying capacity) is found to be susceptible to analysis by the shear-strain-energy and not the maximum-shear-stress theory of failure.

A. R. Bobrowsky, USA

477. G. V. Oozhik, "Method of determining the resistance of metals to cohesive failure" (in Russian), *Bull. Acad. Sci. USSR Ser. tech. Sci. (Izv. Akad. Nauk SSSR Ser. tekh. Nauk)*, Oct. 1948, no. 10, pp. 1547–1560.

For a notched bar it is always possible to make a choice of the shape and of the depth of the notch in such a way that plastic flow occurs only in a small region immediately in contact with the notch, while in the central portion of the section a brittle failure occurs. The axial component of the stress has its maximum value far exceeding the normal strength of the metal at the line of contact between the plastic and the brittle zone.

In this paper it is proposed to use this value as a measure of the real resistance of metals to cohesive failure. It can be calculated on the basis of the work of Neuber from experimental rupture strength of the notched and unnotched bar. Some calculations of experimental results are given.

The author emphasizes (as a new point of view) that the local increase of stress value over the strength of the unnotched bar is due to the lateral stress components in the notched bar.

G. Masing, Germany

478. C. Gurney and P. W. Rowe, "The effect of radial pressure on the flow and fracture of reinforced plastic rods," *Rep. Memo. aero. Res. Counc. Lond.*, no. 2283, May 1945 (issued in 1948), pp. 1–10.

Tension test data are compared with the results of radial-pressure tests on several reinforced plastics. The radial-pressure tests were run in an apparatus in which hydrostatic pressure could be applied to the cylindrical surface of a round bar, while the ends of the specimen extend to the outside. By means of a special extensometer attached to these ends the axial strain of the specimen could be measured. It was found that the axial strain at fracture in the radial-pressure tests was several times the corresponding strain in pure tension. The stress distribution in the radial-pressure specimens and the probable causes of fracture are discussed. Specimens covered with a thin metal sheath broke at approximately the same pressure as those for which the pressure fluid was in direct contact with the specimen.

The primary cause of fracture was thought to be due to the heavy shearing strains and the resulting tensile stresses at the region where the specimen extended out from the pressure chamber.

Evan A. Davis, USA

479. Jacob Porter Frankel, "Relative strengths of Portland cement mortar in bending under various loading conditions," *J. Amer. Concr. Inst.*, Sept. 1948, vol. 20, pp. 21–32.

The statistical theory of failure of brittle materials attempts to explain the large difference in the values of the ultimate stress of these materials when obtained from specimens of different sizes or from specimens loaded in different ways. The author applies this theory to Portland cement mortar and performs tests on beams under sixth, third and center-point loadings. The agreement between theoretical and experimental results is very good. This study will be useful to designers of concrete structures and to stress analysts using brittle coatings or methods using models of brittle materials.

A. J. Durelli, USA

480. J. H. Andrew and Hsun Lee, "Internal stresses and the formation of hair-line cracks in steel," *Inst. Metals Monogr. Rep. Ser.*, no. 5, 1948, pp. 265–273.

Hydrogen can exist in steel in two different forms: as atomic hydrogen in interstitial solid solution and as molecular hydrogen occluded in the mass. The atomic hydrogen diffuses, enters internal cavities and exerts pressures which may cause hairline cracks. Occlusion occurs at crystallite boundaries, and so the amount which can be accommodated without cracking increases with cold work or other means of decreasing crystallite size.

D. C. Drucker, USA

481. C. Gurney and S. Pearson, "The effect of length on the strength of a steel wire," *Rep. Memo. aero. Res. Counc. Lond.*, no. 2158, Nov. 1945 (issued in 1947), pp. 1–13.

This paper describes methods of estimating size effect from the scatter of test results. A very large number of tests are necessary to obtain a reasonable estimate of the effect of size upon the

strength. The authors conclude that a practically important size effect is to be expected in materials with large variation in strength of normally identical pieces. A brittle material may be expected to fail at the breaking stress of the weakest of n elements of which the material may be considered to be composed.

The theory applies only to a material which is statistically homogeneous. Most materials used in engineering are not statistically homogeneous and the theory can be expected to give only trends in such cases. C. O. Dohrenwend, USA

482. **F. P. Bowden, "The experiments of Boas and Honeycombe on internal stresses due to anisotropic thermal expansion of pure metals and alloys,"** *Inst. Metals Monogr. Rep. Ser.*, no. 5, 1948, pp. 275–280.

The paper discusses recent experiments and ideas of Boas and Honeycombe on cracks and slip lines produced in noncubic metals and alloys but not in cubic metals by repeated cycles of heating and cooling. It is shown that the effect is probably due to internal stresses set up at grain boundaries by anisotropy of thermal expansion, and hence is weak if the metal has a strongly preferred orientation and is absent in a single crystal. Annealing of polycrystalline noncubic metals releases the stresses at elevated temperature and reintroduces them to a considerable extent as the metal cools. D. C. Drucker, USA

483. **H. Kastner, "Concerning the Mohr theory of failure Betrachtungen zur Mohrschen Theorie der Bruchgefahr),"** *Ost. Ingen.-Arch.*, July 1948, vol. 2, no. 4, pp. 298–309.

On the basis of considerations regarding the nature of molecular forces in a crystalline lattice, the author proposes certain modifications in Mohr's theory of failure. From the variation of the attractive and repulsive forces on an elementary particle, a general expression for the stress-strain relationship is derived, which indicates the importance of lateral restraint in the strength of axially loaded specimens. Hence it is concluded that not only the maximum and minimum values of the principal stresses, as assumed in Mohr's theory, but also the magnitude of the intermediate principal stress, is likely to have an influence on the ultimate strength. This leads to a recommendation of certain changes in the graphical representation of Mohr's limiting stress envelope. M. Hétényi, USA

484. **C. Gurney and Z. Borysowski, "Delayed fracture of materials under tension, torsion and compression,"** *Proc. phys. Soc. Lond.*, Nov. 1948, vol. 61, pp. 446–452.

In this very interesting paper the time for fracture of certain materials under constant stress and subject to chemical attack is studied. Tension, torsion and compression stress tests were performed on specimens of brass in ammonia vapor, polymerized methyl methacrylate in liquid carbon tetrachloride, and glass in air.

In the cases tested this so-called "delayed" fracture was attributed to the gradual growth of cracks caused by the preferential attack of the surrounding medium on the material under high stress. Transverse fractures were noted for tension specimens, helical fractures for torsion, while for the compression experiments, no delayed fracture occurred.

Curves of stress against the logarithm of time indicated clearly this time delay for fracture, and in general the curves resembled fatigue test curves. For brass in ammonia the times for fracture were similar for tension and torsion when the principal stresses were of the same magnitude, while for the methyl methacrylate equal times for fracture in tension and torsion were produced by higher principal stresses in torsion. Louis F. Coffin, Jr., USA

Design Factors, Meaning of Material Tests

485. **W. H. Bruckner and N. M. Newmark, "Axial tension impact tests of structural steels,"** *Weld. Res. Suppl.*, Feb. 1949, vol. 14, pp. 67–88.

Tension impact tests were made on six steels at temperatures ranging from −100 F to 220 F. The standard specimen finally adopted was $^5/_8$ in. in diameter encircled by a notch of U-section. The root diameter at the base of the notch was 0.294 in. and the radius of the U was 0.039 in. The tests were made in a Riehle impact machine at velocities from 8 to 18 fps and striking energies from 45 to 220 ft-lb. (A few tests were made with 22.5 ft-lb striking energy.) The energy expended in producing fracture and the reduction of area were recorded.

The object of the tests was to find for each material the transition temperature, as indicated by a sharp change in the fracture energy or the area reduction, and to compare these transition temperatures with those that had previously been determined from static tests on wide notched specimens of the same materials. There was agreement between transition temperatures based on fracture energy and those based on area reduction. For some materials, the transition temperature appeared to decrease with decreasing initial impact energy, while for others no change was apparent. The transition temperatures at the lower impact energies are in good agreement with those from the static tests on wide notched specimens mentioned above. M. P. White, USA

486. **S. M. Feinberg, "The principle of limiting stress"** (in Russian), *Appl. Math. Mech. (Prikl. Mat. Mekh.)*, Jan.-Feb. 1948, vol. 12, pp. 63–68.

The paper is concerned with applications of a heuristic principle which, in the engineering literature, is sometimes referred to as the "principle of the intelligence of the material." Defining an "admissible state of stress" in an elastoplastic structure as a state of stress which satisfies all conditions of equilibrium and nowhere exceeds the yield condition, the author formulates his principle as follows: If for a structure under given loads admissible states of stress exist, then one of them actually occurs in the structure; this principle is supposed to hold no matter how the loads have been brought up to the given values.

With each admissible state S a positive multiplier λ is associated; it is defined as the greatest positive number by which the stresses of S can be multiplied without exceeding the yield condition. If the validity of the principle of limiting stress is accepted, the safety factor of the structure under given loads is obtained as the maximum of λ for all admissible states of stress. If, for example, the octahedral shearing stress σ_0 is accepted as the yield criterion, the "deviation of a given state of stress from zero" is defined as the maximum value of σ_0 for this state of stress. The state of stress which furnishes the safety factor is then characterized as that admissible state of stress which possesses the smallest deviation from zero. The author indicates briefly how upper and lower bounds could be obtained for the safety factor, but does not give any examples. W. Prager, USA

Material Test Techniques

(See also Revs. 465, 477, 481, 485, 554)

487. **J. Miklowitz, "The influence of the dimensional factors on the mode of yielding and fracture in medium carbon steel—I,"** *J. appl. Mech.*, Sept. 1948, vol. 15, pp. 274–287.

This paper reports a detailed experimental study of the local principal strains occurring in flat steel tensile bars during uniform over-all straining to failure. Both geometry and size were shown

to produce large variations of the local necking strains. The test program included width to thickness ratios from 1 to 10, length to thickness ratios from 5 to 50, and specimen cross-sectional areas ranging from 0.035 in.^{2} to 5.6 in.^{2}.

Henry W. Foster, USA

Mechanical Properties of Specific Materials

(See also Revs. 459, 467, 469, 478, 479, 480, 482, 484, 485, 487)

488. R. L. Moore, "Bearing strengths of some aluminum-alloy rolled and extruded sections," *Nat. adv. Comm. Aero. tech. Note*, no. 1503, Sept. 1948, pp. 1–17.

Tests of a number of aluminum-alloy specimens lead to proposed ratios of bearing properties to tensile properties (yield and ultimate, at edge distances of 1.5 and 2 pin diameters) for rolled bars of 75S-T, 24S-T, 14S-W and 14S-T, and for 14S-W and 14S-T extrusions. The thicknesses varied up to two inches. These ratios are reasonably consistent with standards for other common structural aluminum alloys.

John E. Goldberg, USA

489. C. Gurney and P. W. Rowe, "Fracture of glass rods in bending and under radial pressure," *Rep. Memo. aero. Res. Counc. Lond.*, no. 2284, Nov. 1945 (issued in 1948), pp. 1–5.

The authors start from the assumption that surface microcracks and their resulting high stress concentrations are responsible for the observed low tensile strengths of commercial glass rods. They then demonstrate that the same high tensile stresses would be produced at the base of the microcracks by a radial pressure, provided the transmitting fluid enters the cracks. Since radial pressures are much easier to apply to glass rods than an axial tension, they suggest that tests under radial pressure replace tensile tests. Toward this end they give a comparison of fracture tests under radial pressure and under tensile stresses produced in bending. The observations confirm their thesis.

Clarence Zener, USA

490. S. I. Liu and G. Sachs, "The flow and fracture characteristics of the aluminum alloy 24S-T after alternating tension and compression," *Metals Technol.*, June 1948, vol. 15, T. P. no. 2392, pp. 1–12.

Data are given on the effects of a single cycle of preliminary tensile and compressive straining on the retained ductility and tensile strength of aluminum alloy 24S-T. The tensile prestrain varied between 0.06 and 0.28 and the subsequent compressive strain varied between approximately -0.008 and -0.60. Further tests were made on notched specimens.

It is concluded that the ductility reduced by a certain prestrain in tension is partially restored by a subsequent straining in compression. The maximum restoration is obtained when the two strains are approximately equal. When the subsequent compressive strain is very large the flow stress in tension is almost independent of both the tensile prestrain and subsequent compressive strain.

Marshall Holt, USA

491. M. A. Craven, "Sand grading influence on air entrainment in concrete," *J. Amer. Concr. Inst.*, Nov. 1948, vol. 20, pp. 205–215.

An experimental investigation is described which shows that, generally, the percentage of air entrained in concrete increases with decrease in fineness of the sand used. This is the case with ordinary concrete and also when air-entraining agents are used. It is remarkable that the use of 7D4, a new agent developed at the University of California, gave higher strengths than could be obtained without it, in spite of a considerable increase of air entrained.

M. Reiner, Israel

492. Thomas E. Leontis, "The room and elevated temperature properties of some sand cast magnesium-base alloys containing zinc," *Metals Technol.*, June 1948, vol. 15, T.P. no. 2371, pp. 1–35.

The paper covers investigations performed to develop magnesium-base alloys with properties at elevated temperatures superior to those of commercially available magnesium alloys.

In the case of the binary alloys containing up to 10 per cent zinc, appreciable improvement in tensile strength, hardness and creep resistance was obtained at temperatures up to 500 F, the most pronounced improvements occurring in the range 0 to 6 per cent zinc. The addition of small amounts of one or more other elements, such as aluminum, cadmium, calcium, cerium, manganese or zirconium, to form ternary or more complex alloys conferred additional benefits. For example, the addition of 0.5 per cent Mn or 1 per cent Zr to an alloy containing 6 per cent Zn more than doubled the creep limit at 300 F and gave a fourfold increase at 400 F.

At room temperature the outstanding feature of the zinc-containing alloys is their high ductility, which is about twice that of the high-strength commercial alloy AZ92-HTA, while the yield and ultimate tensile strength are equivalent to those of the commercial alloy. At 300 F the zinc alloys have about the same tensile strength as the strongest commercial alloy, and at 400 F they are markedly superior in tensile strength and in ductility.

The investigations reported were exploratory, and although the results were very promising the author recognizes that a number of other factors such as foundry characteristics would need investigation before the alloys could be regarded as commercially satisfactory.

H. A. Wills, Australia

493. L. J. Klingler and G. Sachs, "Fracturing characteristics of aluminum-alloy plate," *J. aero. Sci.*, Dec. 1948, vol. 15, pp. 731–734.

The fracture stress, ductility, and the angle between the normal to the fracture surface and the specimen axis, were investigated as a function of the orientation of cylindrical tensile specimens in $1^1/_2$-in. 24S-T plate.

Seven planes were selected perpendicular to the rolled surface, representing different orientations, including those in the transverse and rolling directions. Specimens were chosen in each of these planes such that their axes made progressively larger angles with the normal (thickness direction). For specimens in a given plane, it was found that the fracture angle (angle between the normal to the fracture surface and the specimen axis) was approximately 40 deg for angles between the specimen axis and the rolling plane from 0 deg to 52 deg. For orientation angles greater than 52 deg the fracture angle decreased. When the specimen axis coincided with the plate normal, the fracture surface was parallel to the rolling plane. The fracture stress and ductility showed the reverse trend, being constant over the region where the fracture angle is changing and rising to a maximum for specimens taken in the rolling direction.

Macrostudies indicated planes of weakness parallel to the rolling plane. However, the anisotropy of fracture properties could not be correlated with these planes by any simple fracture law.

W. F. Brown, Jr., USA

494. **E. A. Owen, Y. H. Liu, and D. P. Morris, "Behaviour of stressed aluminum at room temperature,"** *Phil. Mag.*, Nov. 1948, vol. 39, pp. 831–845.

This is an investigation by X-ray diffraction determinations of the lattice parameter of the recovery, recrystallization and grain growth of high-purity aluminum and aluminum containing pure elements, after removal of stresses. Aluminum plates were subjected to various amounts of compression. Upon release of load, the change in lattice parameter with time at room temperature was measured. (Pure aluminum recrystallizes at zero C.) The lattice parameter immediately after release was larger than for annealed material; it decreased with time (the greater the compression the faster) and approached a constant value, which was higher than the equilibrium value and independent of the amount of deformation. Annealing at 500 C restored the lattice parameter to its original equilibrium value. The parameter immediately after compression exhibited a maximum after about 25 per cent reduction in thickness.

Powder prepared from the high-purity aluminum plate was rolled into foil between sheets of aluminum and the change in lattice parameter with time observed. The behavior differed from that of the plate in that the parameter decreased to the equilibrium value obtained on annealed material.

The effects of both soluble and insoluble impurities upon the above phenomena were studied. Parameter measurements were also made on filed and polished surfaces of the high-purity aluminum plate.

The data are valuable; however, some of the explanations offered for the observed phenomena are open to question.

Harry Schwartzbart, USA

Mechanics of Forming and Cutting

(See Rev. 534)

Hydraulics; Cavitation; Transport

(See Rev. 516, 534)

Incompressible Flow: Laminar; Viscous

(See also Revs. 429, 513, 517, 549, 550, 556)

495. **B. Thwaites, "A method of aerofoil design, Part I. Symmetrical aerofoils; Part II. Cambered aerofoils,"** *Rep. Memo. aero. Res. Counc. Lond.*, no. 2166, May 1945 (issued in 1948), pp. 1–9; no. 2167, Sept. 1945 (issued in 1948), pp. 1–13.

In Part I, the problem of determining the shape of a symmetric airfoil at zero lift coefficient to conform to a specified velocity distribution over its surface is treated. The method, in general, follows the procedure devised by S. Goldstein but is extended so as to permit arbitrary velocity distributions, the mathematical equations for which are unknown, to be treated. In Part II, the method is extended to deal with cambered airfoils. The methods developed assume, in general, the approximations of thin airfoil theory and are considered to be adequate for engineering application.

The author is apparently unaware of a number of methods which have been developed in the United States for the treatment of the so-called inverse airfoil problem. It is the reviewer's opinion that, while the methods proposed by the author employ only relatively simple numerical computations, the user must have a greater familiarity with the problem of airfoil design than these American methods require.

In Part II, the author treats the design of a cambered airfoil as one problem rather than treating the camber line and thickness distribution separately and then in combination. This results in some additional complications as regards the judgment of a user in setting up the problem, but it is claimed, contrary to the opinion of the reviewer, that by treating camber and thickness simultaneously a more efficient airfoil design results.

H. Julian Allen, USA

496. **Georges Bouligand, "Dragging of a viscous liquid in an annular container (Entrainement d'un liquide visqueux dans un vase annulaire),"** *C. R. Acad. Sci. Paris*, June 28, 1948, vol. 226, pp. 2106–2108.

In two previous notes [*C. R. Acad. Sci. Paris*, 1948, vol. 226, p. 1571 and p. 1776], the author considered the general form of the solution of the problem of an annular vessel containing a viscous incompressible fluid with the walls suddenly subjected to a time-dependent angular acceleration. The present note concerns the existence of such solutions. The problem of an infinite liquid-filled cylinder moved from rest in a direction perpendicular to its axis is also briefly discussed. J. S. Isenberg, USA

497. **Maurice Roy, "Theoretical and median flow in a rotor with radial blades (Écoulement théorique et médiane dans un rotor à palettes radiales),"** *C. R. Acad. Sci. Paris*, Aug. 30, 1948, vol. 227, pp. 496–498.

The flow of an inviscid incompressible fluid in a rotating rotor having N radial flat blades is discussed. The vanishing of the axial components of velocity at one cross section of the rotor is taken as a boundary condition.

Courtesy of Mathematical Reviews George Carrier, USA

Compressible Flow, Gas Dynamics

(See also Revs. 511, 512, 520, 530, 531)

498. **C. L. Dailey and F. C. Wood, "Computation curves for compressible fluid problems,"** John Wiley & Sons, New York, 1949. Paper, 8.5 × 11 in., 33 pp., 32 charts, $2.

Thirty-two graphs are given for the following relations:

I. Energy relations: pressure, density, temperature and area ratios as functions of the Mach number, for $\gamma = 1.40$, 1.35, 1.30 and 1.25. For a constant-area channel: an auxiliary function of the Mach number, stagnation pressure and pressure ratios as functions of the Mach number.

II. Plane shocks: shock angle, limiting Mach number, stagnation pressure ratio, pressure ratio, density ratio, temperature ratio, back Mach number, entropy change, Rayleigh-Pitot relation and deflection of the Prandtl-Meyer solution as functions of the free-stream Mach number.

III. Conical shocks: shock angle at the nose, stagnation pressure ratio, surface Mach number, cone surface velocity and surface pressure as functions of the free-stream Mach number; pressure function for cone angles at 5-deg intervals and streamline angles as functions of the polar-angle tangent.

Thirty-three introductory pages explain the basic formulas involved and the use of the graphs. A. W. Wundheiler, USA

499. **John Dugundji, "An investigation of the detached shock in front of a body of revolution,"** *J. aero. Sci.*, Dec. 1948, vol. 15, pp. 699–705.

An investigation of flows after a detached shock wave produced by a body of revolution in a uniform supersonic stream is carried

out as the continuation of the work of Lin and Rubinow. The present author applies the method of power expansion (up to the third power) to find the product of the shock distance and the curvature at the shock vertex as a function of the free-stream Mach number and the similar product at the tip of the body. The predicted values agree reasonably well with the experimental data of Charters, Ladenburg and others. As the author points out, in order to improve the accuracy, consideration of higher-order terms seems to be necessary. S. S. Shu, USA

500. Robert V. Hess and Clifford S. Gardner, "Study by the Prandtl-Glauert method of compressibility effects and critical Mach number for ellipsoids of various aspect ratios and thickness ratios," *Nat. adv. Comm. Aero. tech. Note*, no. 1792, Jan. 1949, pp. 1–26.

Calculations are made of the incremental velocities due to compressibility in flows around thin ellipsoids at zero angle of attack, for free-stream Mach numbers from 0 to 1.0. All aspect ratios are included, from elliptic cylinder (infinite span) to ellipsoid of revolution (span equal to maximum thickness). Reduction in aspect ratio from infinity to two increases the critical Mach number by 0.03 or 0.04 (for respective thickness ratios 0.1 and 0.2).

The results appear to be in satisfactory qualitative agreement with observations of minimum drag as function of Mach number and aspect ratio. The calculations are based on a form of the Prandtl-Glauert approximation suitable for three dimensions. A derivation and comparison with more exact methods are included. Philip Rudnick, USA

501. Frédéric Zerner, "On plane supersonic jets (Sur les jets supersoniques plans)," *C. R. Acad. Sci. Paris*, July 19, 1948, vol. 227, pp. 175–177.

The problem of supersonic plane jets is generally solved numerically or graphically with the aid of the method of characteristics. The author proposes to use the Legendre transformation and construct the solution in the hodograph plane. The condition on the transformed potential χ at the free surface is first derived and then χ is constructed by using either the method of successive approximations or the method of Riemann. The second method reduces the problem to that of solving an integro-differential equation. The author does not mention the possibility of singularities in the Legendre transformation, which causes the breakdown of solution so constructed and the appearance of shocks.

Courtesy of Mathematical Reviews H. S. Tsien, USA

502. A. D. Young and G. L. Green, "Tests of high-speed flow in diffusers of rectangular cross-section," *Rep. Memo. aero. Res. Counc. Lond.*, no. 2201, July 1944 (issued in 1947), pp. 1–31.

The paper includes a detailed description of diffusers and their testing apparatus, as well as a development of the mathematical theory required to interpret the results of the tests.

The diffusers tested were all of constant width, with the same entry and exit areas, the ratio of these areas being 1:4. The semiangles ranged from about 4 deg to about 16 deg. The investigation included measurements of the losses involved, of the pressure distribution along the diffusers, of the total head distributions at the exits, and observations by means of a schlieren installation of the flow and shock-wave patterns in the diffusers. Photographs and curves of the results are included. The tests were carried in each case from a low entry Mach number to well beyond the point at which the diffusers choked.

The main conclusions are: (*a*) For entry Mach numbers below choking, the optimum semiangle for minimum loss is about 4 deg to 5 deg. (*b*) For entry Mach numbers above choking, all diffusers become very inefficient. (*c*) The losses in a wide-angled diffuser can be very effectively reduced by means of a dividing vane. Nicholas Di Pinto, USA

503. R. M. Snow and E. A. Bonney, "Aerodynamic characteristics of wings at supersonic speeds," *Bur. Ord. Bumblebee Ser. Rep.*, no. 55, Mar. 1947, pp. 1–60.

This is essentially a collection of internal memorandums of the Applied Physics Laboratory of The Johns Hopkins University, dealing with the aerodynamic characteristics of finite span wings at supersonic speeds, calculated on the basis of linearized flow. Emphasis is on the design point of view.

In his portion of the paper, the first-named author considers problems in conical flow and with one exception considers wings with supersonic leading and trailing edges. By the Chaplygin transformation [H. J. Stewart, *Quart. appl. Math.*, Oct. 1946, vol. 4, p. 246] the problem is essentially reduced to the solution of Laplace's equation inside a circle, subject to boundary conditions on the circle and on a radial slit. The techniques of complex function theory may then be employed. The rectangular, trapezoidal, raked, and symmetric quadrilateral (about the line of flight) wings are considered. The "raked" wing is trapezoidal, but has the shorter of the parallel edges downstream. Formulas for lift coefficient, center of pressure, and the velocity component yielding the pressure are given. Some or all of the problems considered here have been attacked by somewhat different methods by Busemann [*Schr. deutsch. Akad. Luftf.*, 1943, vol. 7, p. 105], Schlichting [*Luftfahrtforsch.*, vol. 13, pp. 320–335], Lagerstrom [*Nat. adv. Comm. Aero. tech. Note*, no. 1685, Aug. 1948], and Puckett and Stewart [*J. aero. Sci.*, 1947, vol. 14, p. 567].

The second-named author presents expressions for lift, drag, and center of pressure of the rectangular wing, using the Busemann [*Handb. exp. Phys.*, vol. 4, p. 343] second-order theory for the portion of the wing in two-dimensional flow and the now classical correction (contained in the Snow paper) for the portion within the tip cones. He then gives optimum values of aspect ratio, angle of attack, and lift/drag for a given allowable stress, airfoil section, and Mach number for a wing supported all along its base or by a hub. A similar but incomplete discussion is given for the delta wing with sub- and supersonic leading edge, drawing on the results of Puckett [*J. aero. Sci.*, 1946, vol. 13, p. 475] and those of Snow contained in the present paper.

An extensive set of graphs and tables is included, drawn both from the authors' discussion and the papers of the bibliography. These, together with the formulas included, make the paper valuable from a design standpoint, although it does not include the results or analysis of the recent work of Evvard [*Nat. adv. Comm. Aero. tech. Note*, nos. 1382, 1484, and 1585], Lagerstrom [*Nat. adv. Comm. Aero. tech. Note*, no. 1685], and others. Graphs from the Puckett and Stewart paper mentioned before are included, but no analysis of the results of this paper is made.

William H. Pell, USA

504. Holt Ashley, "Applications of the theory of free molecule flow to aeronautics," *J. aero. Sci.*, Feb. 1949, vol. 16, pp. 95–104.

An analysis is made of the forces experienced by a body flying in an extremely rarefied atmosphere such as is to be found from about 120 to 220 km above the earth's surface. At these altitudes the atmosphere can be considered to be composed of free molecules, and the principles of kinetic theory of gases can be used. The Maxwellian distribution is assumed for the thermal velocities, and the opposite extremes of specular, or elastic, reflec-

tion and diffuse reflection are considered for the re-emission of molecules from the surface of the body.

A table of two different standard atmospheres is computed, using NACA methods. These atmospheres consist of atomic oxygen O and molecular nitrogen N_2 for the one, and atomic O and N for the other. Lift and drag coefficients are computed for certain simple bodies (such as a sphere, a flat plate and a right circular cylinder) and plotted against free-stream Mach number. In addition, techniques are developed for finding analytically or numerically the forces on any object in free molecular flow.

Harvard Lomax, USA

505. **Isao Imai and Seiichi Ōyama, "The third approximation of the thin-wing-expansion method for compressible fluids"** (in Japanese), *Rep. Inst. Sci. Technol. Tokyo*, Mar.-Apr. 1948, vol. 2, pp. 37–39.

This paper deals with the third approximation of the method proposed by Isao Imai for solving the equations of compressible flow past a thin airfoil [*Rep. aero. Res. Inst. Tokyo*, 1944, no. 294].

Denoting the velocity potential and the stream function by Φ and Ψ respectively, a uniform flow is expressed as $\Phi = x$, $\Psi = y$. When a thin airfoil is present in this flow, Φ and Ψ can be written as follows:

$$\Phi = x + \phi_1 + \phi_2 + \ldots, \Psi = y + \psi_1 + \psi_2 + \ldots,$$

where indexes 1, 2, 3, ... denote small quantities of the order $0(\epsilon)$, $0(\epsilon^2)$, etc. Writing $x = \xi$, $y = \eta/\mu$, $\psi = \mu\chi$, $\mu = (1 - M^2)^{1/2}$, where M is the Mach number of the undisturbed flow, and introducing complex variables $\zeta = \xi + i\eta$, $\bar{\zeta} = \xi - i\eta$, and complex velocity potential $G = \phi + i\chi$, it follows that $G_1 = f(\zeta)$, where $f(\zeta)$ is an analytic function of ζ. G_2 involves another analytic function $f_2(\zeta)$ besides the terms derived from $f(\zeta)$ and $\bar{f}(\bar{\zeta})$.

In this paper an analytical expression for G_3 is presented which involves an analytic function $f_3(\zeta)$ besides the terms derived from f, $\bar{f}$ and G_2, $\bar{G}_2$. Thus G is written to the third approximation as $G = G_1 + G_2 + G_3$, and $f(\zeta)$, $f_2(\zeta)$, $f_3(\zeta)$ are determined from consideration of the boundary conditions.

Humio Tamaki, Japan

506. **Isao Imai and Seiichi Ōyama, "Application of the method of thin-wing-expansion to gas flow along a sinusoidal wall"** (in Japanese), *Rep. Inst. Sci. Technol. Tokyo*, Mar.-Apr. 1948, vol. 2, pp. 39–44.

In this paper the transonic flow along a sinusoidal wall, $y = \epsilon \sin x$, is investigated by the thin-wing-expansion method which was proposed by one of the authors (I. Imai) and developed to the third approximation by the authors [*Rep. Inst. Sci. Technol. Tokyo*, 1948, vol. 2, pp. 37–39]. The results of calculations show that a continuous solution exists which involves both sub- and supersonic regions, but the solution seems to diverge as the curvature of the velocity distribution curve along the surface tends to infinity at the point of maximum velocity. This seems to imply the appearance of a shock wave. Humio Tamaki, Japan

507. **Joseph V. Foa and George Rudinger, "On the addition of heat to a gas flowing in a pipe at subsonic speed,"** *J. aero. Sci.*, Feb. 1949, vol. 16, pp. 84–94.

The problem of heat addition to a gas flowing at a subsonic speed in a duct of constant cross-sectional area is examined. It is shown that the addition of heat modifies the flow parameters upstream as well as downstream of the region of heat addition in a manner depending on the boundary condition. The following conclusions are reached:

1 The Mach number does not necessarily increase on heat addition; it may also decrease, depending on the boundary conditions.

2 The static temperature of the gas increases continuously when heat is added within the range of initial Mach numbers from $\gamma^{-1/2}$ to 1.0 (γ is ratio of specific heats).

3 The attainment of sonic velocity in the heated region does not limit the amount of heat that can be added.

4 The mass flow may decrease as a result of the addition of heat. This result is not related to the eventual attainment of sonic velocity.

These conclusions are contrary to the opinions expressed by many previous authors. Various numerical examples are given.

H. C. Brinkman, Holland

508. **Hilda Geiringer, "On numerical methods in wave interaction problems,"** *Advances in Applied Mechanics*, Academic Press Inc., New York, 1948, vol. 1, pp. 201–248.

The problem treated is that of the gas flow arising when a gas-filled cylindrical tube, moving axially as a solid body, is suddenly stopped. Isentropic shock is assumed first, and the Riemann portion of the solution is presented in complete numerical detail for a nonviscous adiabatic perfect gas: a uniform shock front moves uniformly from the front end until it meets (for $t = t_0$) the front of the expansion wave which originates at the rear end of the tube. The histories of all the gas particles are given by means of exact numerical formulas (for $\gamma = 1.4$). The conditions for $t \geq t_0$ constitute the new problem.

The equation of motion, $x_{tt} = \gamma x_\psi{}^\gamma \psi_x{}^{\gamma+1}$ (in appropriate units, ψ being the original abscissa and particle label), is replaced by a difference equation. The position-particle (x, γ) curves at the instant t—to be called C_t—form the framework of the numerical method: one point on $C_{t-\Delta t}$, and three on C_t determine one point on $C_{t+\Delta t}$; and C_t is known for $t \leq t_0$. The key step is the determination of the "shocked" particle $\bar{\psi}$ on C by means of the shock conditions $\Delta\psi = M\,\Delta t$, M being the mass-flow rate. The shock front meets the tail of the expansion wave (at some time T) and continues uniformly to the wall: the formulas are given for $t > T$. Much numerical and specific detail is given about the period $t_0 \leq t \leq T$, and numerical insights into the problem of shock-expansion wave interaction promised.

The same method works for nonisentropic shocks, if the third shock condition is used. The computations are described without numerical illustrations.

An account is then given of two suggestions how to dodge the shock conditions. One, due to von Neumann, replaces ψ by a discrete variable n and the partial equation

$$x_{tt} = -\partial p/\partial\psi,\ p = p(\tau),\ \tau = \partial x/\partial\psi,$$

by a system of ordinary equations

$$\ddot{x}_n = p(x_n - x_{n-1}) - p(x_{n+1} - x_n),$$

thus representing the continuous fluid by a finite system of particles. The associated numerical computations are presented, and the particle motion is compared with the one previously obtained: the difference noted consists in oscillations about the average path, and these oscillations are surmised to be the counterpart of the shock.

The other suggestion, due to von Mises, is to find numerically the continuous solution of the flow equations taking viscosity into account. A. W. Wundheiler, USA

509. **Hsue-Shen Tsien and Judson R. Baron, "Airfoils in slightly supersonic flow,"** *J. aero. Sci.*, Jan. 1949, vol. 16, pp. 55–64.

The present paper concerns the calculation of the forces on two-dimensional wedge profiles in a slightly supersonic flow. First the oblique shock and Prandtl-Meyer expansion relations are simplified for the case of small supersonic Mach numbers by means of the transonic law of similarity. The results are then applied to the computation of the aerodynamic forces over a flat plate and over an asymmetric wedge profile using the "shock-expansion" method. The theory is therefore restricted to purely supersonic flows. Curves for the above cases are then plotted, showing the variation of the lift, drag, and moment coefficients with the angle of attack, and the variation of the lift coefficient with the Mach number. Hideo Yoshihara, USA

Turbulence, Boundary Layer, etc.

510. J. M. Wild, "The boundary layer of yawed infinite wings," *J. aero. Sci.*, Jan. 1949, vol. 16, pp. 41–45.

The three-dimensional boundary-layer phenomena on a yawed infinite wing have been investigated through extension of Pohlhausen's two-dimensional methods to determine boundary-layer velocity components in the spanwise direction. Retaining the same degree of approximation as in the two-dimensional solutions, a suitable quartic expression is obtained for the spanwise velocity components. The method of isoclines is used for the determination of the boundary-layer thicknesses and the direction of flow of the spanwise velocity component.

The results of a numerical example for an infinite elliptic cylinder with a ratio of major to minor axis of 6 to 1 at a 7-deg angle of attack (maximum lift) are presented, making use of Howarth's unyawed solution for this particular shape. Comparison of the graphs of calculated results and observations of typical swept-back wings with yarn tufts at the surface indicated qualitative agreement for the strong spanwise flow in the boundary layer. The author suggests that the same procedure should be useful for heat-transfer calculations. Richard G. Folsom, USA

511. Henry G. Lew, "On the compressible boundary layer over a flat plate with uniform suction," *Reissner Anniv. Vol.*, J. W. Edwards, Ann Arbor, 1949, pp. 43–60.

The author solves the problem of laminar compressible boundary layer of a perfect gas over a flat plate without pressure gradient but with constant suction velocity through the porous wall of the plate. The Prandtl number is assumed to be unity, and the viscosity coefficient to vary as a constant power of the absolute temperature. The method used is the modified von Kármán-Pohlhausen method by Dorodnitzyn [*C. R. Acad. Sci. USSR*, 1942, vol. 34, pp. 213–219]. The skin friction coefficient, the velocity profile and the boundary-layer thickness are calculated with two assumed classes of velocity profiles: the quartic profiles and the exponential profiles. The quartic solution is, however, limited below a certain value of Reynolds number by impossible velocity profiles. At equal values of Reynolds number, the exponential profile gives higher values of the friction coefficient.

H. S. Tsien, USA

Aerodynamics of Flight; Wind Forces

(See also Revs. 430, 495, 503, 510, 531, 549, 553, 558)

512. Manley J. Hood and H. Julian Allen, "The problem of longitudinal stability and control at high speeds," *Nat. adv. Comm. Aero. Rep.*, no. 767, 1943 (publ. in 1947), pp. 1–5.

Some causes of the difficulties experienced with many airplanes in pulling out of high-speed dives at subsonic speeds are discussed together with known means for improving the dive recovery.

Using a simplified expression for static stability in pitch, and the results of wind-tunnel tests on models of several airplanes, the authors show that the difficulty in dive recovery is due primarily to a marked decrease in the lift-curve slope of the wing and in the downwash at the tail plane, as the Mach number is increased above the critical value for the wing. Flexibility of the airframe is not considered. J. M. Evans, Australia

513. Carlo Ferrari, "A rapid approximate method for computing aerodynamic characteristics of cascades of airfoils (Un metodo rapido approssimato di calcolo delle caratteristiche aerodinamiche delle schiere di profili alari)," *Atti Accad. Torino*, 1945-46, 1946-47 (issued in 1948), vols. 81–82, no. 1, pp. 264–283.

The approximate method given, of calculating the potential flow at small incidence past a cascade of congruent airfoils of small thickness and camber, is based on the theory of slightly non-uniform flow past isolated airfoils.

Courtesy of Mathematical Reviews M. J. Lighthill, USA

Aeroelasticity (Flutter, Divergence, etc.)

(See also Rev. 464)

514. J. Morris and G. S. Green, "The pitching vibrations of an aircraft," *Rep. Memo. aero. Res. Counc. Lond.*, no. 2291, Aug. 1945 (issued in 1949), pp. 1–23.

A method is presented for determining the symmetric mode shapes and frequencies of a complete airplane with freedom in vertical translation and pitch. The method entails replacement of the continuous system by a set of discrete elastically connected masses. The elastic properties of the system are described by a set of flexibility-influence coefficients. The method is applied to a single-engine fighter aircraft for which ground vibration-test data are available. The equations of motion are solved by the escalator process, a process of numerical solution of the frequency equation for which the senior author is well known. The calculated and experimental results compare reasonably well, the first two natural frequencies being some 10 per cent below the corresponding experimental values, and the third some 10 per cent above the experimental value. R. L. Bisplinghoff, USA

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 425, 497)

515. P. Destival, "French turbo-propeller and turbo-reaction engines," *J. roy. aero. Soc.*, Feb. 1949, vol. 53, pp. 111–136.

This lecture recounts the French wartime development of aircraft gas turbines—a development that was largely carried out under cover during the occupation, without any knowledge of the parallel British and German efforts. The state of isolation in which this work was accomplished is reflected in the originality of several design features. Of particular interest is the experience gained with the use of vaporized fuel.

Joseph V. Foa, USA

Flow and Flight Test Techniques

516. **David R. Brown, William C. Galloway, Jack B. Robertson, and Gene A. Silvey, "A self-contained recording pressure gauge,"** *Rev. sci. Instrum.*, Jan. 1949, vol. 20, pp. 27–30.

The description and operation of a self-starting recording pressure gage is presented. The action of external pressure deflects the plain gage diaphragm which actuates the time-axis starting mechanism and recording stylus. The recording period is five seconds and maximum allowable pressure is 1200 psi. Typical calibration curves for time axis and diaphragm deflection are included in addition to a sample pressure record. The useful frequency range is stated to be 0 to 200 cps.

Richard G. Folsom, USA

517. **F. Cheers, "Note on wind-tunnel contractions,"** *Rep. Memo. aero. Res. Counc. Lond.*, no. 2137, Mar. 1945 (issued in 1947), pp. 1–7.

The wall contour for a two-dimensional contraction is designed by means of the well-known method of conformal mapping. A continuously rising velocity along the whole length of the nozzle is the objective. The wall contour is different from those in use at present, having a relatively long low-speed region and a very short high-speed region. The advantage of this design lies in the utilization of the first-mentioned region as the settling length, and in a uniform velocity distribution (owing to a thin boundary layer) at the exit of the nozzle. Otto Conrad, Germany

Thermodynamics

(See also Revs. 504, 507, 515, 530, 533, 536, 554)

518. **Harold J. Hoge, Cyril H. Meyers, and Robert E. McCoskey, "Charts of compressibility factors and charts showing quantities delivered by commercial cylinders for hydrogen, nitrogen, and oxygen,"** *Nat. Bur. Stands. misc. Publ.*, no. M191, Nov. 17, 1948, pp. 1–4.

Two sets of charts for commercial H_2, N_2, and O_2 are given accompanied by a pamphlet describing their use. They will be useful for rapid determination of quantity of these gases delivered under known conditions of pressure and temperature.

Ahmed D. Kafadar, USA

519. **H. M. Elsey and L. C. Flowers, "Equilibria in Freon-12-water systems,"** *Refrig. Engng.*, Feb. 1949, vol. 57, no. 2, pp. 153–157.

Experimental data are presented for the equilibrium vapor pressures of water and Freon-12, in mixtures containing small amounts of water. Correlation on the basis of ideal-solution theory is given. The data are useful for field-checking of water content in refrigeration systems. Myron Tribus, USA

520. **J. O. Hirschfelder and J. L. Magee, "Thermodynamic properties of air at high-temperatures,"** *U.S. atom. energy Comm. Doc.*, no. MDDC-590, Jan. 1, 1947, pp. 1–49.

The approximate thermodynamic properties of air at high temperatures have been tabulated in two sections. The first section is essentially an extension of the tables of Brinkley, Kirkwood, and Richardson, and has been made to fit the published values of Bethe and Fuchs, Kynch, and Peierls, with only a slight amount of smoothing. In the second section, the equation of state has been put into a form suitable for IBM machine or characteristic calculations. This involved a considerable amount of smoothing and some loss of accuracy, but should serve for studying the qualitative and semiquantitative features of the hydrodynamics of shocks in air.

The authors point out the desirability of greater accuracy, and estimate the amount of labor which would be required. In one table a function is tabulated for determining the temperature when the pressure and density are known, for densities between 20 and 0.0001 times the normal density of air and in the temperature range between 1,000,000 K and 1000 K.

Wm. H. Sparing, USA

Heat Transfer; Diffusion

(See also Revs. 542, 543, 551)

521. **M. Blackman, Alfred Egerton, and E. V. Truter, "Heat transfer by radiation to surfaces at low temperatures,"** *Proc. roy. Soc. Lond. Ser. A*, Aug. 12, 1948, vol. 194, pp. 147–169.

The heat transfer between the walls of vacuum vessels is measured by means of an apparatus consisting of two identical double-walled vacuum vessels constructed of Pyrex glass. The inner vessels and the jacketed necks are filled with liquid oxygen (the liquid oxygen in the neck jackets preventing any heat flow through the neck). The spaces between the inner and outer vessels of both vacuum vessels are connected with the same vacuum system. The heat transferred (mainly by radiation) through the vacuum space is measured by the rate of evaporation of the liquid oxygen. The inner surfaces of the outer vessels and the outer surfaces of the inner vessels can be coated with different metallic layers.

The measured rates of heat transfer are listed for a number of different metallic coatings and show that the surface absorbing the least heat at 90 K is polished copper which is reduced after polishing, to eliminate oxides.

The above experimental results are compared with heat-transfer values based upon the absorptivity calculated by means of measured electrical conductivities (the relations of Maxwell and Drude). The great discrepancy indicated between the experimental results and the calculated values based on electrical conductivity measurements show that the heat transfer through the vacuum space of liquid-gas containers is greatly underestimated by using the conductivity method. It is not fully explained at present why the Maxwell-Drude relations do not give correct results for surfaces at very low temperature.

E. Haenni, USA

522. **Sidney Weinbaum and H. L. Wheeler, Jr., "Heat transfer in sweat-cooled porous metals,"** *J. appl. Phys.*, Jan. 1949, vol. 20, pp. 113–122.

Walls exposed to very high temperatures on one side may be cooled by constructing the wall of a porous material through which a coolant fluid is forced from the low-temperature surface to the surface exposed to the high temperature. The authors present the general solution for determining the steady-state temperature distributions of the fluid and of the porous material for the case of a slab (wall) and of a hollow cylinder the inside surface of which is exposed to the high temperature.

The mathematical analysis is made on an idealized porous material consisting of a simple network of parallel identical cylindrical channels arranged normal to the wall surface. It is shown that the local temperatures of the coolant and of the porous material are almost constant throughout the wall. This statement is illustrated by data from an experiment on a porous wall for which the measured temperatures of the fluid before entering the wall, of the cold surface, and of the heated surface were, respectively, 68 F, 208 F, and 218 F. For this case the analysis

indicated that the difference in temperature between the coolant and the porous material was decreased to less than 0.01 F within 0.0001 in. of the cold wall surface.

In order to account for variation of the unit conductance with coolant flow rate per unit area normal to the flow, the authors offer a refinement of the analysis for which the local unit conductance is allowed to vary as a power of the radius of the cylinder. However, by analogy to laminar flow through ducts, for the conditions of coolant flow which obtain in the porous wall the unit conductance is probably not a function of flow rate. This refinement of the analysis thus appears unnecessary. F. Romie, USA

523. Ragnar Holm, "Calculation of the temperature development in a contact heated in the contact surface, and application to the problem of the temperature rise in a sliding contact," *J. appl. Phys.*, Apr. 1948, vol. 19, pp. 361–366.

In this paper the author extends his work in the field of electric contacts to the case of the temperature rise in a sliding contact where the heat is generated by friction. The ideal system proposed is a semi-infinite space limited by a plane surface containing a circular area in which heat is generated at a uniform rate.

In the application of this solution to the case of sliding contacts, heat generation in the contact surface is limited at each point to the time of contact. Assumptions are made as to the size of the contact surface based on earlier investigations of the author.

Comparisons with experimentally observed temperature rises in bimetallic sliding contacts are also presented. The author was apparently unaware of the paper, "The theory of moving sources of heat and its application to metal treatments," by Daniel Rosenthal [*Trans. Amer. Soc. mech. Engrs.*, 1946, vol. 68, pp. 849–865], which represents a more complete solution of the same type of problem. Myron Tribus, USA

Theoretical and Experimental Methods

(See also Revs. 420, 427, 443, 471, 546)

524. Blanche H. Dalton, "Sources of engineering information," Univ. of Calif., Berkeley, 1948. Cloth, 9.5 × 6.2 in., 109 pp., $1.

This useful booklet contains (1) a list of indexes to periodical and serial literature; (2) a list of abstracting journals, and periodicals containing abstract sections; (3) a list of publications listing journals available at certain locations; (4) a list of bibliographies by subject matter; (5) a list of reference books; (6) remarks concerning lists of trade-catalog collections; (7) a list of bodies concerned with standards and specifications.

All technical libraries will certainly find this book indispensable. When scanning the imposing list of abstracting services one cannot refrain from sighing sadly about too many cooks. The book came out too early to mention Applied Mechanics Reviews.
A. W. Wundheiler, USA

525. J. L. Synge, "The method of the hypercircle in function-space for boundary-value problems," *Proc. roy. Soc. Lond. Ser. A*, Dec. 3, 1947, vol. 191, pp. 447–467.

The author applies the notions of function space, as defined in an earlier paper by Prager and Synge on boundary-value problems in elasticity, to the Dirichlet and Neumann problems in Riemannian N-space, to vibration problems and to slightly more general elastostatic problems. As before, the boundary-value problem is split into two relaxed problems such that a common solution of the relaxed problems is the solution of the original problem. Next it is decided what set of functions shall correspond to a vector in function space. Finally, a suitable definition of the scalar product of two vectors in function space gives a metric in this space. From this point on the procedure is to locate the solution of the problem on or inside a hypercircle in function space, where center and radius of the hypercircle are determined by means of suitable solutions of the relaxed problems.
Courtesy of Mathematical Reviews E. Reissner, USA

526. F. Zwicky, "The morphological method of analysis and construction," *Courant Anniv. Vol.*, Interscience Publishers, New York, 1948, pp. 461–470.

This interesting paper contains essentially a theory of technical research. It opens however, with much broader considerations (for instance, about communicable and uncommunicable truth) whose scope is then rapidly narrowed down.

As an example of application of his "morphological method" the author considers the problem of establishing a list of all things which serve a certain purpose. This, it may be noted, is the basic problem of the professional inventor. The author then advises that the totality of the qualitative and quantitative parameters which are relevant to the problem be listed. He only says at this point that this should be attempted; but in the rest of the paper he seems to assume tacitly and boldly that this basic list is actually exhaustive.

"A morphological box or manifold is (then) constructed with these parameters as its axes or dimensionalities. Such a manifold is made up of many compartments containing the things which embody the answer to the originally proposed problem..... Completeness of the morphological manifold has been achieved if no compartment contains more than one thing or object. Some compartments may be empty.....The final phase of the morphological approach consists in the....construction....of the things contained in the morphological manifold." This is an excellent method of analysis which, the reviewer has reason to believe, is currently applied by the research departments of several large corporations. It is one of the principal points by which their work differs from that of the lone inventor who takes an occasional patent.

However, it must always be recognized that the field of analysis cannot be wider than that of the analyst's imagination. For instance, Legendre "proved" Euler's theorem on polyhedrons, $V + F = E + 2$, but he did not imagine that a polyhedron could have a hole, in which case $V + F = E$. Or again, the Meissner patent on feed-back oscillators covered all types of electric and magnetic couplings, but did not cover electromechanical couplings, as in a sustained tuning fork. Scientific and technical examples of this sort could be quoted without end.

But, it being understood that absolute exhaustiveness is unobtainable, the author's morphological method will certainly, within the limits of a specific morphological box, "stimulate invention" and "point the way to new discoveries."

There are other minor points in this generally worth-while paper. Toward the end, the author devotes a good deal of space to proving that the possibility of mankind blowing up the planet should not be ruled out. Yet this is quite generally viewed with alarm, in the editorials of our daily press and on the Sunday radio, so that the author's proof does not seem very necessary.
P. LeCorbeiller, USA

Acoustics

(See also Revs. 426, 427)

527. **R. D. Spence, "The diffraction of sound by circular disks and apertures,"** *J. acoust. Soc. Amer.*, July 1948, vol. 20, pp. 380–386.

The author studies the diffraction of sound by circular disks and apertures. Confining himself to the case of a plane monochromatic incident wave traveling in the axial direction, he expands the scattered velocity potential into a series of products of zero-order oblate-spheroidal wave functions, namely,

$$\psi = \Sigma A_l u_l(\eta)\,{}^{(3)}v_l(\xi).$$

The angular wave functions $u_l(\eta)$ are presented in the form of power series with coefficients satisfying a homogeneous linear difference equation of the second order, for example, for l even, $u_l(\eta) = \Sigma_0^\infty C_{2k}(1 - \eta^2)^k$. The radial functions (representing divergent waves) are defined as a combination of two standing-wave radial functions, ${}^{(3)}v_l(\xi) = {}^{(1)}v_l(\xi) + i\,{}^{(2)}v_l(\xi)$, in which

$${}^{(1)}v_l(\xi) = \Sigma_0^\infty a_{2\nu}\xi^{2\nu},$$

$${}^{(2)}v_l(\xi) = Q_l[(\tan^{-1}\xi - {}^1/_2\pi)\,{}^{(1)}v_l(\xi) + \Sigma_0^\infty b_{2\nu+1}\xi^{2\nu+1}],$$

where the a's satisfy a homogeneous linear difference equation of the second order, while the b's follow from a similar inhomogeneous equation depending on the a's; Q_l is a constant of normalization. The radial functions are related to the angular functions by

$${}^{(1)}v_l(\xi) = {}^1/_2 q_l \int_{-1}^{1} e^{i\epsilon\xi\eta}u_l(\eta)\,d\eta,$$

$${}^{(3)}v_l(\xi) = q_l \int_{i\infty}^{1} e^{i\epsilon\xi\eta}u_l(\eta)\,d\eta,$$

where $\epsilon = 2\pi$ is the radius of the obstacle divided by the wave length and q_l is a constant of proportionality. Expansions in terms of spherical Bessel and Hankel functions follow at once from these integral representations. Expressions are given for the scattering cross sections of the disk and the aperture; numerical results are plotted in diagrams for $0 \leqq \epsilon \leqq 5$. During the preparation of the paper the author was unaware of similar work by the reviewer [Thesis, Groningen, 1941] including numerical results for $0 \leqq \epsilon \leqq 10$.

Courtesy of Mathematical Reviews C. J. Bouwkamp, USA

528. **E. N. Fox, "The diffraction of sound pulses by an infinitely long strip,"** *Phil. Trans. roy. Soc. Lond. Ser. A*, no. 828, June 1948, vol. 241, pp. 71–103.

The author obtains the solution for the two-dimensional diffraction problem of a perfectly reflecting strip subject to a plane pulse of constant unit pressure at normal incidence. The problem is formulated as an inhomogeneous integral equation

$$\pi = \lambda \int_0^\infty A\,[y']K_0\,[\lambda|y - y'|]\,dy' + \lambda \int_0^\infty A\,[y']K_0\,[\lambda(1 + y + y')]dy',\ y > 0, \ldots (1)$$

where $A(y')$ is the function desired and is related to the pressure function, and K_0 is Macdonald's Bessel function of order zero. Upon noting that the absence of the second term in the above integral equation provides an integral equation of the Wiener-Hopf type, a method of successive substitutions is suggested as a means of solution for (1). Excitation pulses of different shape are also discussed and some of the results are presented in numerical form. The above methods have been applied to several other two-dimensional diffraction problems and these results are promised in a later paper.

Courtesy of Mathematical Reviews A. E. Heins, USA

529. **John W. Miles, "The diffraction of a sound wave by an infinite set of plates,"** *J. acoust. Soc. Amer.*, July 1948, vol. 20, pp. 370–374.

It was suggested by Schwinger that the special class of electromagnetic boundary-value problems where a plane wave is incident upon a number of semi-infinite perfectly conducting parallel planes or cylinders can all be formulated as Wiener-Hopf integral equations and solved exactly. The case of an infinite set of parallel staggered semi-infinite plates was discussed in detail by Carlson and Heins [*Quart. appl. Math.*, 1947: vol. 4, pp. 313–329; vol. 5, pp. 82–88]. The problem of the diffraction of sound waves by a similar structure is equivalent to the electromagnetic problem discussed in the second Carlson-Heins paper. It is discussed in the present paper, and the conditions for plane wave propagation within the plates, for a single reflected wave, and expressions for the reflection and transmission coefficients are given.

Courtesy of Mathematical Reviews E. T. Copson, USA

Ballistics, Detonics (Explosions)

(See also Rev. 522)

530. **S. S. Penner and D. Altman, "Adiabatic flow of hydrogen gas through a rocket nozzle with and without composition change,"** *J. Franklin Inst.*, May 1948, vol. 245, pp. 421–432.

The authors examine the problem of adiabatic flow through a nozzle of a rocket combustion chamber with the assumption that complete equilibrium is reached at each temperature ($H_2 \leftrightarrows 2H$), and also that the number of mols dissociated per initial unit concentration is very small. The fundamental thermodynamic equations are set up and from them graphs are computed to exhibit the variation of pressure p, $(1/p)(dp/dT)$, gas velocity v, $(1/v)(dv/dt)$ with respect to T. The results are used to show that the nozzle expansion ratio required is greater with composition change than without.

No practical results are quoted. The graphs enable the designer to appreciate the limits between which the practical results must lie, and it may well be that the curves given in this paper are nearer to the truth than the well-known results without composition change. R. C. Knight, England

531. **Mårten Blomqvist, "Optimum surface smoothness of projectiles (Optimal ytjämnhet hos projektiler),"** *Teknisk Tidskr.*, Oct. 16, 1948, vol. 78, pp. 657–661.

From a ballistic point of view, a very smooth surface of the projectile is desired, which however, increases the manufacturing costs. In order to determine the optimum, measurements of the air resistance for different surface conditions were made in 1944 at the Royal Institute of Technology in Stockholm.

A 20-mm projectile with surface profile depths $H = 0.65$, 15 and 60μ showed that the resistance of the last-mentioned depth was 8.5 per cent higher than that of the first one. The resistance curve increases asymptotically to a value slightly higher than the one at 60μ. Continued tests proved that the machining feed s also influenced the air resistance, which is a function of H/s. At H/s equal to about 0.15 maximum resistance is obtained.

Painting of the surface results in a change of the resistance: for a smooth surface, in an increase, and for a rough surface, in a decrease. Tables are given for obtaining the desired smoothness of the surface from the machining operations; they have been tested at the Sandvikens Jernverk. W. Weibull, Sweden

532. **Robert Genty, "On the problems of escape from the earth's attraction and gravitation around the earth (Sur les problèmes de l'evasion hors de l'attraction terrestre et de la gravitation autour de la Terre),"** *C. R. Acad. Sci. Paris*, May 10, 1948, vol. 226, pp. 1510–1512.

For rockets, the familiar hypothesis of ballisticians concerning acceleration with constant weight is no longer tenable. The author therefore reopens the question. He first secures a well-known formula. The limitations of mechanical possibilities call for further study, which leads to a simple formula for velocity that takes account both of the radial distance from the earth's center at the point of departure and at the point marking the end of burning, with incidental recognition of the variation of gravitational attraction with altitude. Air resistance is ignored throughout.

Courtesy of Mathematical Reviews A. A. Bennett, USA

533. Robert H. Goddard, "Rocket development," Prentice Hall, Inc., New York, 1948. Cloth, 6 × 9.2, 291 pp., 36 figs., $6.50.

This book has considerable historical interest as it is a complete account of the author's work on liquid-fuel rockets, on the ground and in flight, between 1929 and 1941. It can be seen from the day-to-day description of experiments and modifications that this work anticipated many of the developments in rocket propulsion and guidance which are now coming into prominence in the guided-missile field. As examples, a combustion chamber with a porous wall through which oxygen entered for cooling was tested in April 1930. Many alternative methods of supplying the fuels to the combustion chamber were tried, from simple application of pressure to the fuel tanks, to centrifugal fuel pumps driven by compressed-air turbines. Steering of the rockets in flight by vanes in the jet was attempted as early as 1932. Work on propulsion units utilizing atmospheric air, in 1931–33, is closely allied to the ramjet and pulse jet. Stabilization in flight by gyroscopes and servomechanisms is also described.

The author has not attempted to select high lights in the experimental work, but has given a fairly complete description of each stage. The tests, particularly those concerned with improvements in fuel spray jets, were often highly empirical in nature, and this is reflected in the description.

R. Smelt, USA

Soil Mechanics, Seepage

534. J. M. Dallavalle, "Micromeritics," Pitman Publishing Corp., New York, 1948, 2nd ed. Cloth, 9.2 × 6 in., 555 pp., 131 figs., $8.50.

The term and title, *Micromeritics*, was coined by the author for the first (1943) edition of this book to denote the science and technology of fine particles, specifically those ranging in size from 10^{-5} to 1 cm, that is from the lower limit of the microscopic range to the size range of gravel and crushed stone. For this field the author has performed a service similar to that of W. Ostwald for colloid chemistry in his *World of Neglected Dimensions*.

The book covers and coordinates in a very satisfactory way the most important properties of individual fine particles and of systems made up of or containing fine particles as essential constituents. Representative topics are: particle-size measurement and shape and size distribution, dynamics of small particles, theory of sieving and grading of materials, characteristics of packings, behavior under pressure, electrical and optical and sonic properties, thermodynamics of particles, surface and chemical properties, flow of fluids through packings, infiltration and particle-moisture relationships, capillarity, determination of particle surface, muds and slurries, transport of particles, atmospheric and industrial dusts, collection and separation of particulate matter from air, theory of fine grinding, etc.

The theoretical treatment is illustrated with and applied to many phenomena of importance in soil physics, mineral physics, chemical engineering, ground water and petroleum geology, hydrology (silting of streams), wind storms, sand ripple and dune formation, and many others.

This second edition has been extensively rearranged and contains five new chapters. The material is better unified and represents a more complete discussion of the physical behavior of fine particles. While a book of this wide scope cannot give an exhaustive treatment of every topic touched upon, its perusal should be of profit to every scientist and technologist who is interested in the behavior of fine particles.

Hans F. Winterkorn, USA

535. W. Hirst, "The mechanical interaction between mobile insoluble adsorbed films, capillary condensed liquid and fine-structured solids," *Disc. Faraday Soc.*, 1948, no. 3, pp. 22–28.

This work is part of a fundamental investigation of the influence of moisture films on the strength and breakage of coals and of the influence of sorption swelling on the movement of assemblies of fuel particles.

Suggestions are offered on how observations of the changes in dimensions and mechanical properties which accompany adsorption can be made by the use of a number of simple models.

Adsorption isotherms on swelling solids are more difficult to interpret than those on rigid materials. If the adsorbate is insoluble and forms mobile-surface films, the swelling is caused by the spreading force of the film acting on the underlying solid.

Rollie G. Fehrman, USA

536. E. C. W. A. Geuze and C. M. A. de Bruyn, "The first law of thermodynamics and the consolidation process" (in English), *Proc. Sec. int. Conf. Soil Mech. Found. Engng.*, 1948, vol. 3, pp. 29–32.

Experimental settlement versus time curves are presented for the consolidation of clay under various loading rates. It is found that for a given amount of work, the settlement is larger the smaller the rate of loading. The authors explain this on the basis of the fact that the energy dissipated in overcoming the viscosity of the soil solution is proportional to the square of the speed of settlement. Rodney Hill, England

537. A. W. Koppejan, "A formula combining the Terzaghi load-compression relationship and the Buisman secular time effect" (in English), *Proc. Sec. int. Conf. Soil Mech. Found. Engng.*, 1948, vol. 3, pp. 32–37.

On the basis of consolidation tests on various clay soils, an empirical formula is constructed which takes into account the failure of the settlement to reach a constant value during extended observation times. Rodney Hill, England

538. E. S. Barber, "Triaxial compression test results applied to flexible pavement design," *Public Rds.*, Sept. 1947, vol. 25, pp. 1–8.

This is a report of an investigation made by the Public Roads Administration which suggests possible relationships between triaxial-compression-test results and the thickness of flexible pavement. Stresses at a point are evaluated on the assumption that the material is elastic. The effects of shear stresses at the pavement surface resulting from friction between tire and pavement are discussed briefly. Thickness of pavement is considered on the basis of an assumed allowable settlement, overstress at a point and bearing capacity. Various tables and curves are presented.

In the abstract it is stated that "the analyses are not proposed as determinative design procedures but are rather intended as aids in studying the behavior of pavements in service, and as guides in planning and conducting experimental studies of the interaction of pavements and subgrades."

Harry A. Williams, USA

539. **J. H. A. Crockett and R. E. R. Hammond, "The natural oscillation of ground and industrial foundations"** (in English), *Proc. Sec. int. Conf. Soil Mech. Found. Engng.*, 1948, vol. 3, pp. 88–93.

Natural frequencies measured by various investigators for different types of soils are tabulated. The elementary theory of soil vibration is discussed, showing that due to nonlinearity of the spring constant, the frequency varies with amplitude. It is suggested that the equivalent ground mass should be taken as that mass below a foundation in which compressive principal stresses exist. Frequencies of higher orders are briefly discussed.

R. N. Arnold, Scotland

540. **Curt F. Kollbrunner, "Calculation of sheet pile walls in cohesive soil"** (in English), *Proc. Sec. int. Conf. Soil Mech. Found. Engng.*, 1948, vol. 1, pp. 108–115.

Equations are developed for the determination of the effect of the cohesion of the soil on the performance of sheet piles. The point is made that the equations given previously by Jacoby are in error.

Gerald Pickett, USA

541. **A. W. Skempton, "A study of the immediate triaxial test on cohesive soils"** (in English), *Proc. Sec. int. Conf. Soil Mech. Found. Engng.*, 1948, vol. 1, pp. 192–196.

Formulas are derived expressing the pore water pressure in a saturated clay stressed at constant water content in terms of Poisson's ratio and the moduli of compression and swelling. Formulas are also derived expressing the compression strength as measured in the immediate triaxial test in terms of the true cohesion and angle of internal friction.

It is shown that while an immediate triaxial test on saturated clay gives an angle of shearing resistance of zero, the inclination of the shear plane is 45 deg plus half the angle of internal friction. Test data are presented showing that the inclination of the shear plane increases as the porosity decreases.

Edward S. Barber, USA

542. **Miles S. Kersten, "Apparatus for measuring thermal conductivity of soil"** (in English), *Proc. Sec. int. Conf. Soil Mech. Found. Engng.*, 1948, vol. 3, pp. 162–165.

An apparatus for measuring the thermal conductivity of soils is described. The design is based on the same principles as in the hot-plate equipment used for determining thermal conductivities of insulating materials. The test section is in the form of a hollow cylinder of which the inner surface is kept at the desired constant temperature by an electric heating unit. The device is designed so that the moisture content of the sample could be changed.

Ahmed D. Kafadar, USA

543. **Miles S. Kersten, "Thermal conductivity of soils"** (in English), *Proc. Sec. int. Conf. Soil Mech. Found. Engng.*, 1948, vol. 3, pp. 12–15.

Test results on the thermal conductivity of 14 different soils from the Arctic region are given at various densities, moisture contents and mean temperatures. The apparatus described by the author in the paper reviewed in the preceding review is used. The results are analyzed and conclusions are drawn.

In particular, empirical relations are given between the thermal conductivity and moisture contents, and the densities.

Ahmed D. Kafadar, USA

544. **B. Jakobson, "The design of embankments on soft clays,"** *Géotechnique Lond.*, Dec. 1948, vol. 1, pp. 80–90.

A method of analysis is presented for determining the thickness and width of loading berms which are required to control the shearing stresses in a foundation of soft clay supporting a fill. The method is based on the assumptions that the ground surface upon which the fill and protecting berms are constructed is horizontal, that the soil immediately underlying the fill is a homogeneous clay whose shearing strength is constant throughout and that the shearing resistance of the fill and berms is zero. It is assumed, furthermore, that the most critical sliding surface through the foundation is cylindrical in shape and that this surface terminates at the original ground surface.

On the basis of these assumptions a mathematical theory is developed for determining the loading-berm requirements to provide against a foundation failure. The results of the theory are presented graphically to facilitate application to practical problems.

R. E. Fadum, USA

Geophysics, Meteorology, Oceanography

(See also Revs. 429, 539)

545. **Dwight B. Kline, "Investigation of meteorological conditions associated with aircraft icing in layer-type clouds for 1947–48 winter,"** *Nat. adv. Comm. Aero. tech. Note*, no. 1793, Jan. 1949, pp. 1–12.

The data gathered here on icing rates, drop size, and free-water content in wintertime stratus clouds in the Midwest will be useful to practical aeronautics but, due to the limitations of the instruments used (rotating cylinders), they will probably prove of rather restricted value in meteorological research.

Joanne Starr Malkus, USA

546. **H. Philipps, "The gradient-wind nomogram (Gradient-wind-Nomogramm),"** *Z. Met.*, Apr. 1947, vol. 1, pp. 201–211.

For straight isobars the use of nomograms to determine the geostrophic wind is well known in the weather service. The author describes a well-designed nomogram, easy to use for the determination of the gradient wind in the case of curved isobars, if the barometric gradient (distance of isohypses), radius of curvature of the isobars and the latitude are known. The nomogram is explained by some examples. A short theory of nomograms is added, as well as some remarks on the true wind and the degree of its approximation by the gradient wind.

Horst Merbt, Germany

547. **S. L. Hess and H. Wagner, "Atmospheric waves in the northwestern United States,"** *J. Met.*, Feb. 1948, vol. 5, pp. 1–19.

In the first part of this paper the vertical structure of waves in air currents crossing the Rocky Mountains is studied by means of the shape of constant potential temperature surfaces ("isentropic" surfaces). It is shown that if the motion may be taken to be approximately steady-state and dry adiabatic, so that the isentropes are stream surfaces, nodal surfaces are present. This occurs usually at 17,000 ft to 20,000 ft, but in one case as low as 10,000 ft, with downward motion in the lee below and upward motion above.

The chinook-arch cloud occurs in the current above the nodal surface. Because the vertical spreading of the isentropes represents reduced stability, thunderstorms, hail and turbulence would be expected in the lee of the mountain range. The observations are inconclusive as to whether these phenomena are more frequent there than elsewhere.

In the second part it is shown that low-pressure troughs move across from the West Coast to the Great Plains region with speeds greater than the wind speeds at levels up to 20,000 ft. From this it is concluded that these cannot be associated with surface or upper air fronts. The life history of cyclone formation in the lee of the Rockies is shown by means of maps averaging ten cases occurring in January and February, 1945, and the corresponding maps for one of these cases. The average and the individual case show that the lee cyclone development is associated with the movement inland of either a frontal trough or a fast-moving trough. M. Neiburger, USA

548. Ryuma Kawamura, "An apparatus for recording small temperature fluctuations in the atmosphere" (in Japanese), *Rep. Inst. Sci. Technol. Tokyo*, Dec. 1947, vol. 1, pp. 167–171.

A resistance thermometer for recording small temperature fluctuations is described. A fine thermometer wire forms one arm of the Wheatstone bridge, to which alternating current of 2000 to 5000 cps is applied. The bridge voltage, modulated by the variation of resistance of the thermometer wire, is applied to the amplifier circuit, which consists of a two-stage voltage amplifier, detector and power tube, the output being recorded by an electromagnetic oscillograph. Humio Tamaki, Japan

549. Kazuhiko Terada, "On the coefficient of resistance of a sphere and its falling velocity" (in Japanese), *J. met. Soc. Japan*, July 1948, vol. 26, pp. 70–71.

For the resistance coefficient of a sphere at Reynolds number less than 600, the author proposes an empirical formula $C_x = (24/R)(1 + 3R/16)^{1/2}$, where C_x is the resistance coefficient, and R is the Reynolds number related to the diameter. The terminal velocities of raindrops of various diameter calculated from this formula are in good agreement with the observed values.
Humio Tamaki, Japan

550. Otto Dinkelacker, "The directional instability as an aerological means of estimating exchange phenomena in the free atmosphere and its relation to Bjerknes' circulation theorem (Die Richtungstabilität als aerologische Hilfsgrösse zur Abschätzung der Umlagerungsvorgänge in der freien Atmosphäre und ihr Zusammenhang mit dem Zirkulationstheorem von V. Bjerknes)," *Met. Rdsch.*, Nov.-Dec. 1947, vol. 1, pp. 165–168.

Further manipulation with parcel thermodynamics gives rise to some new ways of expressing and computing parcel instability and relating it to one of the terms in the circulation theorem. Since it is likely that the parcel method has outlived its usefulness in meteorology, it is fortunate that the last few sentences of the paper are devoted to the modifications introduced by turbulent mixing, when some of the energy of parcel instability is hypothesized to be transformed actually into that of a growing circulation. Joanne Starr Malkus, USA

551. A. E. Benfield, "The effect of uplift and denudation on underground temperatures," *J. appl. Phys.*, Jan. 1949, vol. 20, pp. 66–70.

It is shown by means of calculations that underground temperatures are affected by the processes of uplift and denudation. The effects of the rates of these processes and the time of operation are illustrated by numerical tables applying to some specific ideal situations. Uplift and denudation increase the heat flow above its equilibrium value, but no very large increase is likely to occur unless the equilibrium heat flow is small and the speed of denudation large.

The respective theoretical calculations agree closely with the data found by Birch in his Colorado well, and with Coster's estimate of the effect of denudation on heat-flow values for Persia.
Hans F. Winterkorn, USA

552. Robert G. Fleagle, "Quantitative analysis of factors influencing pressure change," *J. Met.*, Dec. 1948, vol. 5, pp. 281–292.

The contribution to density change made by compression or expansion, advection and vertical motion, and by horizontal mass divergence or convergence was determined by analysis of data from 132 cases chosen during a period of anticyclogenesis above a polar anticyclone and during two periods of cyclogenesis. The density change in the layer two or three kilometers in thickness just above the tropopause was shown to contribute most to pressure change on the ground. This density change may be considered as the result either of advection in the lower stratosphere or of the excess of horizontal mass divergence over vertical mass divergence.

Advection in the lower stratosphere was found to be closely related to local pressure change and to vertical motion in the upper and middle troposphere (downward motion accompanying rising pressure and advection of denser air, and upward motion accompanying falling pressure and advection of lighter air).
Hans F. Winterkorn, USA

553. D. M. Patterson, "A simplified procedure for the determination of heat requirements of ice protection of fixed areas of aircraft," *CADO tech. Data Dig.*, Feb. 15, 1949, vol. 14, pp. 15–23.

Convenient graphs are presented for use in the design of airplane-wing ice-prevention systems utilizing heat. These graphs reduce the labor required, subject to the following restrictions: (*a*) the water interception is equivalent to a cylinder; (*b*) the intercepted moisture is evaporated; (*c*) the boundary layer is laminar. No new theory is presented but the results will be useful to designers. Myron Tribus, USA

Lubrication; Bearings; Wear

(See also Rev. 534)

554. R. C. Parker and P. R. Marshall, "The measurement of the temperature of sliding surfaces, with particular reference to railway brake blocks," *Proc. Instn. mech. Engrs.*, 1948, vol. 158, no. 2, pp. 209–229, 8 plates.

The first part of this paper concerns techniques for measuring rapidly varying surface temperatures, including the thermoelectric-type pyrometer, the bolometer-type radiometer, the microwave radiometer, and the photoconductive-type pyrometer. An instrument of the latter type was developed employing a lead sulphide photocell, and is described in detail. It covers a temperature range of 390 F to 1650 F and has a response time of only 10^{-4} second.

The second part describes experiments with this instrument to measure railway-tire-surface temperatures just as the tire emerges from beneath the brake block. It is claimed that the temperatures measured are close to those actually existing under the brake block. The tests were full size and included study of the

extent of the area of contact between brake block and tire. The surfaces were found to make contact initially over only small localized areas resulting in only a strip of the brake surface being effective. Surface temperatures over 1470 F were observed, but no temperatures reaching the melting point of the cast iron. The high-temperature bands cause complex distortion of the tire surface, the resulting high spots wearing down quickly and other areas coming into contact with further distortion and wear. The strip-contact areas thus move back and forth across the block.

Brake blocks only 1/4 of the normal length greatly reduced the strip-braking difficulty; the maximum surface temperature was found to fall to below 750 F and the braking time became more consistent. The wear per unit area per unit time was less for the smaller brake block than for the larger standard-size block.

The paper is supplemented by a valuable discussion which is as extensive as the paper itself. Milton C. Shaw, USA

555. **F. P. Bowden and A. J. W. Moore, "Internal stresses produced by the sliding of metals,"** *Inst. Metals Monogr. Rep. Ser.*, no. 5, 1948, pp. 131–137.

When a hemispherical steel surface slides over a copper surface, a clearly defined track is formed. Direct examination shows little apparent difference between the track produced under clean and under lubricated conditions. However, for clean sliding, sections reveal much more severe distortion of the copper beneath the surface of the track. Sections were made at 90 deg to the direction of sliding and 5 deg to the surface of the steel. Study of the clean sliding of copper on steel shows that adhesion and a plucking out of the steel occurs at the interface. When the surfaces are lubricated, a similar process takes place on a reduced scale. When a copper contact slides on a copper surface, the damage is much more severe.

It is concluded that the internal stresses produced below the surface of the copper are formed by the formation and shearing of metallic junctions during sliding. Continued sliding would give a distorted layer extending far beneath the surface.

B. F. Langer, USA

556. **D. Tabor, "Collisions through liquid layers,"** *Engineering*, Feb. 18, 1949, vol. 167, pp. 145–147.

The author presents a study of collisions between metal spheres and between spheres and flat metal surfaces. Experiments with contact surfaces dry and again with films of lubricating oils between the surfaces are discussed. It is found from measured electrical conductance across the area of contact that the viscosity of the oil influences the condition under which metal to metal contact occurs. There are cases in which metal to metal contact does not occur but nevertheless plastic deformation of the metal does occur.

Calculations based on the theory of viscous flow of fluids indicate that fluid pressure in excess of the yield stress for the metal and fluid temperature as high as 3000 C can be developed. Such pressure and temperature conditions have an adverse effect on the lubricant.

The results of the investigation are said to be of importance in the selection of lubricants for such machine elements as gears and bearings. William H. Hoppmann II, USA

557. **P. Boussuges and S. Casacci, "Study of parallel surface thrust bearings (Étude sur les pivots a grains parallèles),"** *Houille blanche*, July-Aug. 1948, vol. 3, pp. 347–355.

This theoretical study of the hydrodynamic lubrication of parallel-surface thrust bearings, which act in accordance with Fogg's principle of constricting the passage area available for flow in the oil film through thermal expansion of the oil [*Proc. Instn. mech. Engrs.*, 1946, vol. 155, War Emergency Issue no. 14, pp. 49–53], embodies the important new feature that the finite width (side leakage) of the oil film is accounted for. The theory has been worked out for thrust bearings with rectangular pads, as well as for thrust bearings with pads shaped in the form of a ring sector. The theory is only an approximate one in so far as it is based on the arbitrary assumption that the film temperature increases linearly in the sliding direction and that it does not vary over the width; the shortcomings of this approximation are balanced to some extent, however, by so adjusting the (constant) temperature gradient that the heat accumulated in the oil flowing out in the sliding direction is equal to the frictional power losses.

The theoretical results were confirmed with some success by measurements of film thickness in the annular thrust bearing (having an outer diameter of about 10 ft) of the turntable of a heavy turret lathe, operated at speeds up to 12 rpm.

There are a few misprints; for instance, Formulas (8′) and (9′) on p. 348 should be interchanged with (8) and (9) on p. 351.

H. Blok, Holland

Marine Engineering Problems

(See also Rev. 430)

558. **Curt Falkemo and Johan Adlercreutz, "Model tests on single-step planing surfaces"** (in English), *Trans. roy. Inst. Technol. Stockh.*, 1948, no. 24, pp. 3–39.

In this paper the authors describe tests which were conducted to determine the fundamental performance of stepped planing surfaces of zero dead rise. The shape of the wetted surface of the planes, the center of pressure, the resistance, the stability and the effects of height of the step and the angle between the two planes in the planing range were accurately determined.

It was found that at a given angle of incidence in the planing range the resistance can always be reduced and the longitudinal stability improved if the planing surface is divided by means of a transverse step of adequate size. Ernest G. Stout, USA

559. **C. A. Lee and C. E. Bowers, "Ship performance in restricted channels,"** *Proc. Amer. Soc. civ. Engrs.*, Apr. 1948, vol. 74, pp. 521–549.

This fifth paper in the symposium "Panama Canal—The Sea-Level Project," summarizes studies conducted at the Taylor Model Basin on the maneuverability and controllability of ships in restricted channels. Models on a 1:45 scale of tankers, Liberty ships, and warships including battleships were studied in channels corresponding to sections 300 to 700 ft wide with 1:1 side slopes. The rudder angles necessary to hold the ships against bank suction were found in tests in which powered models were made to traverse a length of canal. These angles were determined for several speeds and channel depths as a function of the ship's distance from the canal center line.

In other tests Panama Canal pilots attempted to maintain the models on a course parallel to the channel center line at speeds between 5 and 15 knots. These tests substantiated the rudder-angle equilibrium tests. Both tests indicated that ships are much easier to handle in the 60 and 80-ft water depths than in the 45-ft depth studied. The manner in which the rudder-angle data would be applied to the choice of a suitable canal cross section is indicated.

Piloted model tests were also conducted with two ships meeting and passing in the canal. Studies of the suitability of various shaped bends indicated that a curve with no widening was more suitable than one with widening.

A third type of model test, conducted in the circulating-water channel, involved steady-motion measurement of the lateral force and yawing moment developed between the ship and a vertical channel side wall for zero rudder angle and zero yaw of the ship. This type of test also permitted measurement of the rudder angle necessary to counteract the yawing moment and the rudder angle for equilibrium (zero force and moment). Results are presented for a tanker in three widths of channel at three speeds, as a function of distance from the center line. Information was also obtained on the effect of channel depth and width and ship speed on the change in level of a ship resulting from its motion in a restricted channel. J. M. Robertson, USA